4 90e

Ontario

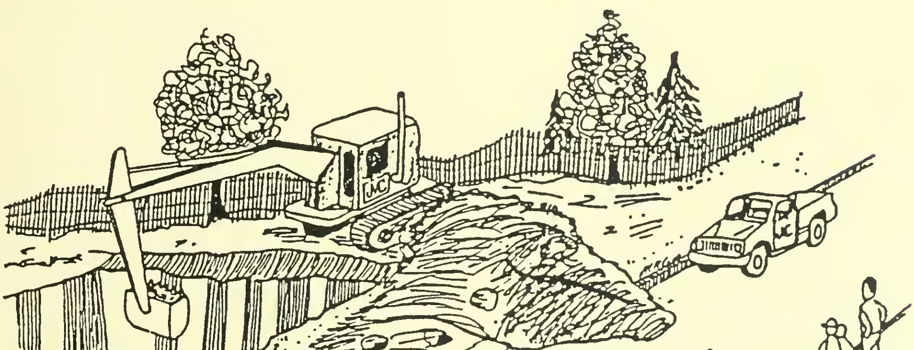
GUIDELINES

ON

EROSION AND SEDIMENT CONTROL

FOR

URBAN CONSTRUCTION SITES



May, 1987

ISBN 0-7778-2248-2

Ontario

Guidelines on

Erosion and Sediment Control

for

Urban Construction Sites

Ontario Ministries of Natural Resources, Environment,
Municipal Affairs and Transportation & Communications
Association of Conservation Authorities of Ontario
Municipal Engineers Association
Urban Development Institute, Ontario.

May, 1987

Reprinted December 1987

Guidelines on Erosion & Sediment Control
for Urban Construction Sites

Table of Contents

LIST OF TABLES

ACKNOWLEDGEMENTS

These Guidelines represent a co-operative effort of several Provincial Ministries, Conservation Authorities, Municipal Engineers Association and Urban Development Institute, and was co-ordinated by Mr. G.S. Sardesai, Ministry of Natural Resources and Mr. V. Chin, Ministry of the Environment.

The principal writer of the Guidelines was Mr. F. I. Lorant of M. M. Dillon Ltd.

A document entitled "Urban Drainage Design Guidelines" will also be issued in the near future. The release of these and other documents relating to Urban Drainage Management in Ontario, is being co-ordinated by the Urban Drainage Implementation Committee comprised of:

Mr. M. R. Garrett, Chairman	Ministry of Natural Resources
Mr. M. G. Lewis, (alternate)	Ministry of Natural Resources
Mr. N. Borodczak	Ministry of the Environment
Mr. L. Fincham	Ministry of Municipal Affairs
Mr. J. Harris	Ministry of Transportation & Communications
Mr. C. Mather	Conservation Authorities of Ontario
Mr. M. Price	Municipal Engineers Association
Mr. J. Knox	Urban Development Institute
Mr. M. Cosburn (alternate)	Urban Development Institute

Guidance during the preparation and review of the Guidelines was provided by a technical sub-committee comprised of:

M. Price, (Chairman)	Municipal Engineers Association
J. Armstrong (Major Contributor)	Ministry of Transportation & Communications
D. Persaud (Major Contributor)	Municipal of the Environment
M. Lewis	Ministry of Natural Resources
R. Anderson	Upper Thames River Conservation Authority
M. German	Ministry of the Environment

Background information was also obtained from a number of publications, particularly those referred to in the Bibliography and the drafts of the Guidelines were reviewed by many practitioners in private, academic and public service.

All of which is gratefully acknowledged.

PREFACE

Guidelines contained in this document are intended to assist with the implementation of erosion and sediment control measures by designers and administrators of the Urban Drainage Management Program in Ontario. These are not intended as rigid procedures, as it is anticipated that those responsible for implementation will continue to utilize innovative approaches which best address specific situations. Downstream owners have certain rights and any drainage system design must recognize and respect these rights.

Recommendations contained in this document were formulated on the basis of selected assumptions. It is important to note that the nature of existing and proposed development, modifications to watercourses, and inherent tolerances in calculation and design techniques, may have significant impact on the accuracy of outputs and on the preferred approach. Advances in technology will also continue to improve the methods and techniques which are currently employed in the design and construction of erosion and sediment control works. It is expected that the implementors will give due recognition to these factors during the decision-making process.

The Provincial Ministries, Association of Conservation Authorities of Ontario, Municipal Engineers Association and the Urban Development Institute therefore, cannot provide any express or implied warranty of any kind and in no event shall be held liable for direct or consequential damages associated with, and/or arising from the performance or use of these Guidelines.

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

During the construction phase of any urban development, eroded sediment during runoff events may increase by one thousand times or more compared to pre-development conditions.

Many people were looking for controls that would limit erosion runoff to a defined specific objective (i.e. x tonnes per hectare). However, the resources required to sample and measure erosion rates and to provide meaningful monitoring of the runoff controls, would not be readily available to the site inspectors. The controls to be considered should be easy to design, implement and inspect.

The approach chosen was to prepare guidelines that would enable a developer or municipality and/or their consultants to evaluate the site erosion potential based on the following basic information:

- slope gradient
- slope length
- soil type

The soil type is a good indication of soil drainage and erodibility. Knowing the soil classification and site topography, three broad classes of soil erodibility have been identified. The simplified process will also enable the local municipality to readily and easily check any developer's evaluation. In the

guidelines, it has been assumed that the natural vegetation on the site has been removed, the topsoil stockpiled and the sub-soil exposed and/or regraded. The soil erodibility is calculated on the exposed sub-soil.

Once the site has been divided into zones of high, medium or low erodibility, and the slope gradient and length have been added, then all regions within the construction site can be labelled as being low, moderate or high erosion potential.

Knowing the potential of the exposed sub-soil for erosion, the next determination is whether or not any eroded soil would leave the site overland or via a sewer system. If all the sediment laden storm drainage could be temporarily ponded on site, then only minimum erosion and sediment controls would be required. However, if sediment laden storm drainage could flow off the site, then the sensitivity of the overland flow route(s) and receiving waterbody must be determined. Environmentally sensitive streams with fish habitats would require extensive control measures, regardless of the erosion potential of the site.

On the other hand, waterbodies with low environmental sensitivity would not require such stringent controls, especially if the site had low erosion potential.

Receiving waterbody sensitivity to sediment laden flow should be determined by the appropriate agency having jurisdiction. Typically this would be the Ministry of the Environment or Ministry of Natural Resources and/or the Conservation Authority. Given the site erosion potential and the sensitivity of the downstream environment, suitable erosion and sedimentation controls can be considered.

From a shopping list of appropriate erosion and sediment control measures for the construction site, the developer and/or municipality can determine which controls to install.

The overall drainage network and spoil piles should be considered for erosion and sediment control measures as well as the zones of erosion potential.

All urban construction sites should consider some minimum control measures to address the environmental pollution caused by: mud tracking onto municipal streets, windblown dust, and water borne sediments entering the municipal sewer system.

Throughout the guidelines, the approach has been to encourage prevention rather than to effect cure; emphasis has therefore been placed on protection of exposed surfaces and the control of runoff. Sediment control is to be practised to prevent off-site sedimentation damage. Generally, this is achieved by filtering

sediment-laden flow or impounding to allow settling out of sediment particles.

During construction periods on the site, the effectiveness of the controls in place has to be visually verified, as well as ensuring proper maintenance is carried out. The municipal inspectors are the first line of defence, and the success of the entire erosion and sediment control strategy will depend on their diligence. If the control measures chosen are not effective, then other methods and controls should be added.

The whole process relies heavily on the individual municipality, and because no specific measurable objective has been defined, (to avoid costly and time consuming monitoring) there will be a degree of judgement to be exercised.

The lists of methods and techniques given in sections B & C of the guidelines consist of proven and commonly used control measures. They are not exhaustive lists, as techniques used for unique situations have not been included. Also, one parameter for the lists chosen was that the methods have low construction costs and require unskilled labour to construct and maintain. In selecting the best method, the designer and contractor or site supervisor must consider feasibility, practicality and cost in relation to the environmental sensitivity of the receiving waterbody.

In conclusion, we believe that a site evaluation process using more than three classes (i.e. high, medium, low) implies a level of precision that is not matched by control methods in the field. To gain the support of practitioners, evaluation schemes should not be too complex, and some discretion in choice of methods to meet their goals must be given. Two of the main factors to consider when determining erosion and sedimentation controls are the sensitivity of the downstream environment and the availability of on-site retention facilities.

SECTION A

CRITERIA AND GUIDELINES

1. INTRODUCTION AND BACKGROUND

The land and water in Ontario watersheds are part of our natural resources. In order to protect these valuable resources from erosion of the land or from pollution of the waters caused by construction activities, it is essential to formulate and adopt criteria, policies and procedures for erosion and sediment control.

The rapid increase in erosion and sedimentation caused by construction activities, if left uncontrolled, can result in serious damage to the environment. High erosion rates can result in loss of valuable topsoil, and the subsequent sedimentation of rivers and lakes can affect water supplies, flood control, fishing, navigation and recreational activities.

Measurements of erosion rates, taken from various land uses, show a wide range of values depending on construction techniques, soil conditions, vegetation, and climate. However, representative erosion rates for construction sites with no erosion control measures are, on the average, 200-400 times higher than the natural erosion rate for rural land use. Population forecasts for Ontario show a 4,000,000 person increase over the next 20 years, which could represent an increase of 800-1000 sq.km in urban land use. As the average erosion rate from an urban construction site is 20,000 tonnes/sq.km /year, uncontrolled

erosion from these new construction areas could produce as much as 16 to 20 million tonnes of sediment, or approximately 4 tonnes of sediment for every new resident.

The purpose of these guidelines is to provide developers, municipalities and review agencies with a practical method for ensuring that urban construction is carried out in such a manner that a minimum amount of soil is eroded from the site and deposited in adjacent watercourses and/or drainage networks.

With the implementation of municipal class environmental assessments, engineers who are planning and designing municipal construction projects will have to identify the impacts of their work on the environment. In the Environmental Study Report, measures will have to be documented that mitigate adverse environmental effects. Erosion and sedimentation requirements are the most common in Appendix 2 of the Class Environmental Assessment for Municipal Road Projects.

The protection of downstream water uses will be a major factor in determining the degree of control to be implemented on the construction site and downstream from it.

The methods outlined in these guidelines can be used for large projects, such as a major subdivision, down to an individual building site. For a small site with a low erosion potential and which is not affecting downstream water uses, the only controls that may be necessary are the general "good house-keeping" practices.

For construction projects that are in or adjacent to watercourses or lakes, special consideration should be given to the method of construction. These cases should be discussed with the appropriate agency having jurisdiction over the waterbody.

Information from a number of existing provincial guidelines such as the Ministry of Environment Water Quality guidelines, and the construction guidelines of the Ministries of Natural Resources, Environment, and Transportation and Communications, have been incorporated in the document.

An excellent resource document for soil erosion and sedimentation associated with construction projects is Chapter F of the Drainage Manual issued by the Ministry of Transportation and Communications.

2. EROSION AND SEDIMENTATION PROCESS

The erosion of soil material from an exposed surface is the result of the detachment of particles by rainfall and runoff. Rain splash describes the process whereby the initial impact of raindrops detaches soil particles and serves as a limited form of transport. Surface runoff, synonymous with overland flow, occurs when the soil becomes saturated and its infiltration capacity is reduced. Overland flow entrains and transports particles first as a thin sheet of water moving over the ground (sheet-erosion) and then, as the flow becomes more concentrated, in minute channels or rills (rill erosion).

Further increases in the velocity and volume of flow, increase the erosive power of the water within the rills which may gradually enlarge into gullies. Sheet, rill and gully erosion are temporary phenomena which occur during and immediately after precipitation events, and which have the potential to carry significant amounts of sediment derived from exposed surfaces into watercourses.

Sedimentation occurs when the internal energy of the flow decreases to the point where particles can no longer be transported. Large particles, such as gravel and coarse sand, will be deposited first, followed by the fine sand, silt, and clay-sized fractions. This process commonly occurs when an increase in channel capacity or decrease in gradient causes a drop in the velocity of a stream.

The erosion potential of any site will depend on the soil cover, soil characteristics, topography, and climate. However, for the purposes of site specific evaluation of construction sites, soil cover and local climate can be ignored. Climate need not be included since it is an independent variable (i.e. cannot be controlled). Seasonal variations tend to be regional and can be accommodated through construction scheduling. For the purposes of this document, soil cover can be ignored since only the "worst case" situation (i.e. where no protective cover is left in place) is considered. The use of existing vegetation for protection will, in itself, be viewed as an erosion control measure.

The topographic evaluation may be based on a consideration of slope length and slope gradient, while soil characteristics may be summarized through a description of soil texture and soil drainage. The guidelines that follow will utilize these four factors to characterize a site as being of low, moderate, or high erosion potential.

This qualitative evaluation of construction site erosion potential will supply the developer and review agencies with the basic information required for the selection and evaluation of appropriate erosion and sediment control measures.

A PROCEDURE FOR THE EROSION AND SEDIMENT CONTROL PROCESS

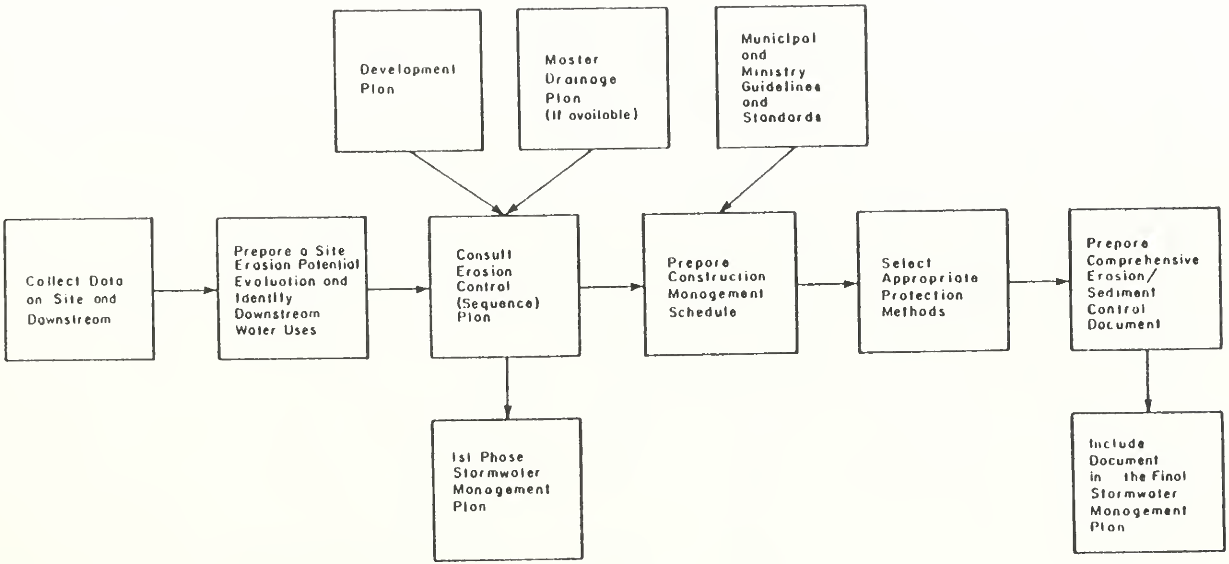


FIGURE 1.

3. PROCEDURE FOR EROSION AND SEDIMENT CONTROL PROCESS

A procedure for erosion and sediment control planning leads systematically from a description of the site and the downstream waterbody, through erosion potential of the site, the downstream environment sensitivity, to specific methods of control. The process is illustrated in Figure 1.

The erosion process involves three basic stages:

detachment - transport - deposition

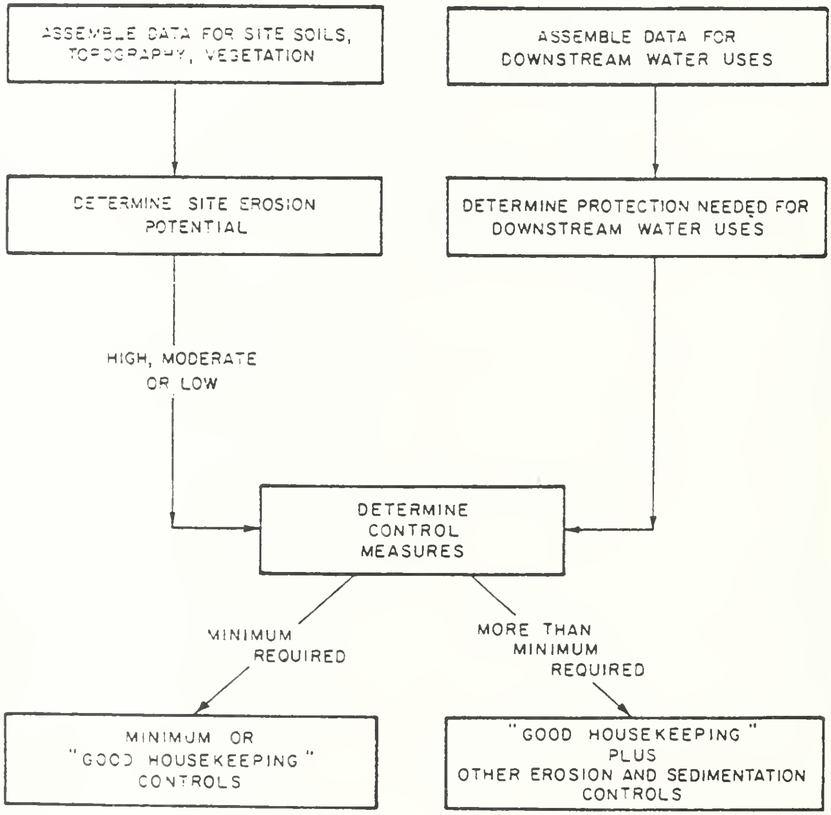
Once the sediment is detached from the land surface, the transport and deposition stages will determine how far the sediment is moved and where it will be deposited. The need for protection of the downstream water uses will determine what control measures will be required in addition to the "good housekeeping" measures.

If the downstream environment is very sensitive to increased turbidity, then on-site controls will have to be considered to give the necessary protection.

Where it is feasible and practical to provide an on-site depression with no outlet, such that all sediment laden stormwater can drain to it, then no erosion controls will be necessary. However, the question of safety, due to permanently ponded water will have to be addressed. Ideally, if the erosion process of detachment, transport and deposition occurs entirely on the construction site, then no erosion controls will be necessary.

FIGURE 2

FLOW CHART FOR EVALUATION OF SITE EROSION POTENTIAL & PROTECTION OF DOWNSTREAM WATER USES



Where storm flows will leave the site along either temporary or permanent routes during construction activities, then both erosion and sedimentation controls will be needed to some degree.

A large number of methods of erosion and sediment control have been published (see bibliography). Generally, they are found in manuals or collections of standards, which describe criteria and specifications in detail. An important step in the erosion control process, is the selection of an appropriate method from the variety available.

In summary, the evaluation analysis required for the erosion control process is shown on the following flow chart, Figure 2, and documented in sections 3.1 and 3.2.

3.1 SITE EROSION POTENTIAL

Site erosion potential is a measure of the erodibility of the site subsoil, where consideration is given to:

- site surface slope gradients;
- length of site slopes;
- soil erodibility (based on soil drainage and soil texture).

When soil particles are picked up by stormwater flowing over the surface, the size of the soil particles, and the quantity transported downslope, will increase with the increase in velocity of the runoff. When moving downslope, a change in the slope to a

flatter gradient will result in a decreased velocity and a decreased transport capacity. At that location, sediment will be deposited, starting with the larger size, followed by smaller particles. In general, long and/or steep slopes are more prone to erosion than short and/or gentle slopes.

As stated earlier, the concern is that material could leave the site, as opposed to the soil being moved by runoff from one part of the site to another. Transported soil can leave the site overland or through the storm sewer system.

The evaluation of a construction site will require large scale topographic mapping. This will be available, in most cases, as part of the information required by the developer prior to the submission of a draft plan, or by the municipality prior to detailed design of any construction work. If this is not available, then existing topographic mapping may be used, at a scale not smaller than 1:2,000 with 1 m contour intervals. It is recommended that the topographic mapping be extended 50 m beyond the boundary of the construction site to ensure that the surrounding topography is taken into account when selecting on site erosion and sediment control measures.

3.1.1 Slope Gradient

On steep slopes, the downslope component of gravity is increased and the component normal to the surface is decreased. This means

that not only is less force per unit area required to entrain particles, but the amount of overland flow is increased. As a result, susceptibility to erosion increases sharply with slope angle.

Gradients should be measured perpendicularly to the contours and computed as a percentage. The slope percentage is the vertical distance divided by the horizontal distance (i.e. a 1:1 slope equals 100% slope). Three slope classes are defined in Table 1 for use in the site evaluation.

TABLE 1

SLOPE GRADIENT CLASSES

Slope* %	Description
0 - 10	Gentle
10 - 15	Moderate
Over 15	Steep

* Vertical distance : horizontal distance between two contours computed as a percentage.

Slope zones should be delineated on the topographic sheet(s) so that all regions within the construction site are labelled according to one of the above slope classes.

Determining the boundaries for both regions of uniform and sharply discontinuous relief will be relatively straightforward.

However, delineation of areas with varying slopes may not be as simple. In some cases it may be necessary to measure the gradient between individual contours (i.e 1 m) to ensure adequate consideration of small scale topographic variations. Despite slight interpretative variation in certain cases, a good general picture of slope gradients throughout the construction site can be obtained in this manner.

Normally the slope gradient analysis is carried out on the original site contours, after stripping topsoil and before any regrading or installation of site services; i.e. the worst case.

If major earth moving takes place to achieve the final site grading, the slope zones considered should be average slopes, taking into account the original and final grades. The number of zones per site should be as few as possible, with emphasis placed on the perimeter of large sites.

3.1.2 Slope Length

The velocity and volume of overland flow tends to increase with slope length and hence, susceptibility to erosion. Slope lengths should be determined for each of the slope zones identified in the previous section by measuring the distance from crest to toe, perpendicularly to the contours (the total length of the slope

should always be used even if it lies partially outside the construction site boundary). These guidelines employ a two class slope length assessment as defined in Table 2.

TABLE 2

SLOPE LENGTH CLASSES

Length *	Description
under 70 metres	Moderate
over 70 metres	Long

* slope length measured down the slope face

Each of the three gradient classes can now be assigned one of two length classes, making a total of six topographic classes.

3.1.3 Soil Erodibility

The soil characteristics of texture and drainage may be used to obtain an estimate of soil erodibility (K) (the ability of the soil to resist entrainment and transport by rain splash and overland flow).

For each of the slope zones identified in section 3.1.1, a determination of soil erodibility is required.

In most cases a construction site evaluation will require

subsurface soil data, since usual construction practice involves the stripping of topsoil. This data should normally be available as part of the geotechnical survey undertaken by the developer prior to the submission of a draft plan, or by the municipality prior to detailed design of any construction work.

Soil Texture

Soil texture refers to the particle sizes of the individual soil grains composing the soil. The relative proportions of sand, silt and clay can be determined through laboratory analysis or field estimation, and used to classify the soil as being coarse textured (sandy), medium textured (loamy), or fine textured (clayey). The organic content need not be considered since in most cases organic material will be removed during the topsoil stripping of a construction site.

Coarse particles are not readily entrained because of their frictional resistance and high infiltration capacity, while clay sized particles have high cohesive strength. As a result, sandy and clayey soils tend to exhibit low erodibility, while loamy soils range from medium to high erodibility.

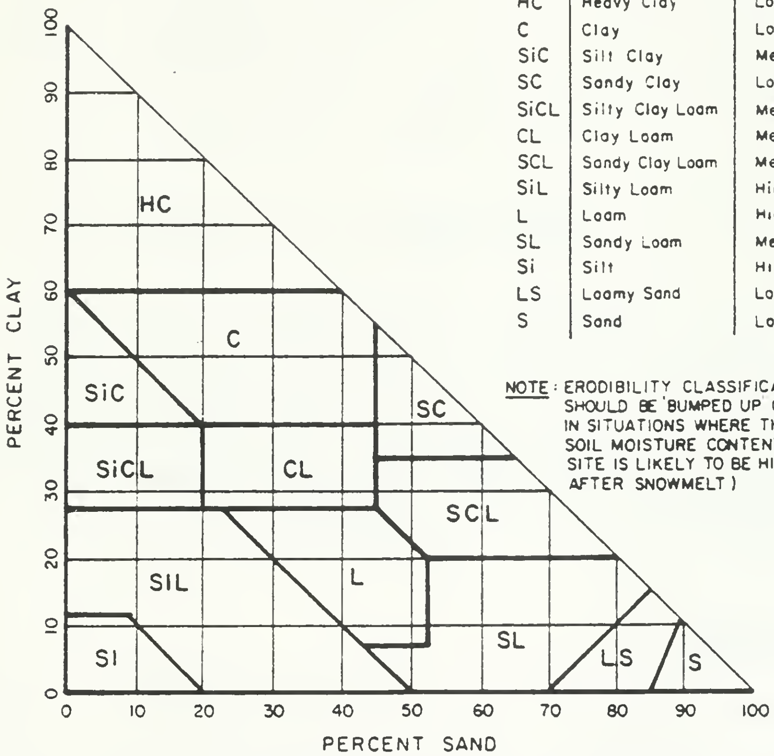
Table 3 can be used to obtain the textural class and associated erodibility of a given soil. The erodibility classification is obviously a simplified one. This three-class approach does provide a good general indication of soil erodibility. In most cases this textural description will incorporate soil drainage

TABLE 3

SOIL ERODIBILITY

KEY	SOIL TYPE	SOIL ERODIBILITY (K)
HC	Heavy Clay	Low
C	Clay	Low
SiC	Silt Clay	Medium
SC	Sandy Clay	Low
SiCL	Silty Clay Loam	Medium
CL	Clay Loam	Medium
SCL	Sandy Clay Loam	Medium
SiL	Silty Loam	High
L	Loam	High
SL	Sandy Loam	Medium
Si	Silt	High
LS	Loamy Sand	Low
S	Sand	Low

NOTE: ERODIBILITY CLASSIFICATIONS (K) SHOULD BE 'BUMPED UP' ONE CLASS IN SITUATIONS WHERE THE INITIAL SOIL MOISTURE CONTENT OF THE SITE IS LIKELY TO BE HIGH. (ie AFTER SNOWMELT)



SOIL TEXTURE CLASSES. PERCENTAGES OF CLAY AND SAND IN THE MAIN TEXTURAL CLASSES OF SOIL; THE REMAINDER OF EACH CLASS IS SILT.

SOIL TEXTURE NOMOGRAPH

characteristics, since permeability (in general) varies directly with grain size.

Although Table 3 includes most of the soil types, additional information on detailed soil types within an area may warrant modification of the soil erodibility classification. For example, while sand is classified as having low soil erodibility, fine sand (not classified) may exhibit medium soil erodibility.

The moisture content of a soil prior to a precipitation event will have a significant influence upon its erodibility. This is readily apparent in the case of poorly drained soils, since the degree of saturation in conjunction with precipitation intensity will determine the infiltration capacity, and hence the amount of erosive overland flow. As a result, the erodibility classifications given in Table 3 should be "bumped up" one class in situations where the initial soil moisture content of the site is likely to be high (i.e. after snowmelt).

Soil Drainage

The infiltration capacity of a soil reflects its ability to drain moisture via the force of gravity. Reduced infiltration results in surface ponding and overland flow which leads to increased surface erosion.

One of the most significant factors affecting soil drainage is soil structure (the arrangement of soil particles), which affects the permeability of the soil (its ability to transmit water

through pore spaces). Soil structure can be adversely affected by heavy machinery which compacts the surface soil and reduces infiltration.

Topography and depth of parent material will also influence the drainage characteristics of a soil since poorly drained soils are frequently found in regions of concave relief, or areas where a thin layer of soil overlies impermeable material.

3.1.4 Evaluation of Site Erosion Potential

Having labelled all regions within a construction site according to slope gradient and length, this topographic information can be combined with the soil characteristics of texture and drainage to yield the various zones of site erosion potential. A procedure is outlined in Table 4.(Note that for steep slopes both length classes are considered equivalent).

TABLE 4

EROSION POTENTIAL

TOPOGRAPHIC CLASSES: GRADIENT ①	TOPOGRAPHIC CLASSES: LENGTH ②	SOIL ERODIBILITY CLASS ③: LOW	SOIL ERODIBILITY CLASS ③: MEDIUM	SOIL ERODIBILITY CLASS ③: HIGH
GENTLE	MODERATE	LOW	LOW	MODERATE
	LONG	LOW	MODERATE	HIGH
MODERATE	MODERATE	LOW	MODERATE	HIGH
	LONG	MODERATE	HIGH	HIGH
STEEP	MODERATE	MODERATE	HIGH	HIGH
	LONG	MODERATE	HIGH	HIGH

EROSION POTENTIAL

NOTE

1. SLOPE GRADIENT CLASS IS DETERMINED FROM TABLE No 1.
2. SLOPE LENGTH CLASS IS DETERMINED FROM TABLE No. 2.
3. SLOPE ERODIBILITY CLASS IS DETERMINED FROM TABLE No. 3

ALL ZONES WITHIN THE CONSTRUCTION SITE SHOULD BE ASSESSED AS BEING OF LOW, MODERATE OR HIGH EROSION POTENTIAL.

3.2 PROTECTION OF DOWNSTREAM WATER USES

The protection of downstream water uses is a consideration as to the degree that erosion and sedimentation controls are required for the site. The nature of the land between the construction site and the receiving watercourse, or waterbody, will have a bearing on the downstream impacts.

Where sediment laden flow would flow overland from the construction site onto public or private property that could not tolerate sediment deposition, then considerable protection would be required.

The need for protection of downstream water uses should be determined from the appropriate agency having jurisdiction. Downstream uses may include recreation, water consumption, flood storage areas, and fish and wildlife habitat. Typical contacts are the local Conservation Authority, the Ministry of Natural Resources, the Ministry of the Environment, municipalities and waterbody users.

Overland flows may cross private property, enter the watercourse and end up in a waterbody. Similarly, piped flows from the site may enter a watercourse and end up in a waterbody. The impact of sediment laden flows on all downstream uses should be assessed and the greatest impact will determine the amount of controls to to be used.

Having determined the severity of the impacts on water uses, then

the need for on-site erosion and sedimentation controls can be assessed.

3.3 EVALUATION SUMMARY

With both the site potential for erosion and the protection of downstream uses integrated, then a determination can be made of the erosion and sediment control measures to be implemented on site and downstream.

The evaluation should take into account that after the topsoil has been stripped from a site, the erosion process could start. Where the site has to be regraded to final elevations, the direction of sediment laden flow could change. Overland flow routes, for both initial and final site grade conditions, should be checked to ensure that the appropriate downstream environment sensitivity has been evaluated.

The route to a receiving watercourse can be overland or via a municipal sewer system. Both routes should be evaluated before and after the final overland flow route(s) is constructed and/or available.

Minimum erosion and sediment control measures will be needed in all instances. These are also referred to as "good housekeeping" measures. If there are impacts on downstream uses, and/or the erosion potential increases, then additional measures will need to be implemented.

The following table outlines the relationship of site erosion potential, the impacts on downstream water uses and the degree of erosion and sediment controls that could be considered.

TABLE 5

DEGREE OF EROSION AND SEDIMENT CONTROL

Site Erosion Potential	Impacts on Downstream Water Uses	Degree of Erosion and Sediment Control
Low	Negligible	Good Housekeeping measures only
	Yes	Consider sedimentation pond(s)
Moderate	Negligible	Erosion and sediment controls
	Yes	Erosion controls and sedimentation pond(s)
High	Negligible	Erosion and sediment controls
	Yes	All flows to on-site sedimentation pond(s)

Selection of the appropriate erosion and sediment control measures for the construction site requires that, in addition to the zones of erosion potential, the initial and ultimate drainage network be highlighted, the inlets and outlets to piped sewer systems be

identified and spoil pile locations be identified.

The information to be included in a first phase stormwater management report should be as follows:-

- large scale map showing zones of erosion potential, overland flow routes, sewer inlets, spoil pile location, and any potential sedimentation pond sites;
- written description of the site, including results of evaluation for site erosion potential, impacts on downstream water uses, any stream dimensions and stream flow data, special features not apparent from the map;
- an indication of the degree of erosion and sediment control measures anticipated, based on the site erosion potential and the protection of the downstream water use(s).

Where the site erosion potential is high and the impact on the downstream water uses is severe, the designer should consider a more detailed analysis and evaluation process, as described in the MTC Drainage Manual, Chapter F, Erosion and Sediment Control.

4. EROSION AND SEDIMENT CONTROL METHODS

Once the evaluation has been carried out to determine the combined effect of erodibility of the site and sensitivity to sedimentation downstream, then appropriate control methods can be determined.

On all urban construction sites, from small individual building sites to large sub-divisions, the contractor should employ a minimum set of control measures to achieve the "good housekeeping" goals listed in Section 4.2.1.

The project designer should be aware that the review of any erosion and sediment control strategy will examine the suitability of proposed control measures according to site conditions and the degree of control required as a result of the evaluation process.

All areas of a site, even those rated as having low erosion potential, will require some "minimum" measure(s) unless the disturbed areas drain to an on-site depression with no outlet. This method of impounding storm flows is a good control feature. However, caution is advised in urban areas where safety to children is of greater concern.

Where sites will have temporary impoundment areas with positive outlet into the sewer system, no erosion control measures need be applied except those considered to achieve the "good housekeeping" goals. Site areas that do not drain to the temporary impoundment area(s) will still require adequate erosion and sediment control measures.

Construction sites without temporary impounding areas will require appropriate erosion and sediment control measures.

These guidelines contain only commonly used control measures which have been demonstrated to be cost-effective and not dependent upon skilled labour. A summary list is provided (see Tables 6 and 7) as a guideline only and should not be interpreted as an exhaustive selection. This list is followed by a series of corresponding standardized description sheets in Sections B and C.

4.1 METHOD OF SELECTION

The selection of specific control methods will be based on:

a) the SITE EVALUATION SUMMARY;

b) season;

c) design requirements;

d) construction requirements;

e) municipal by-laws and guidelines; and

f) cost.

Since effective implementation of control measures is a site-specific operation, the user may choose any combination of the measures listed; modify the measures listed; or supplement the list with other appropriate measures.

Where possible, the relative effectiveness of the measures has been evaluated with the result that certain measures have been designated "minimum". This designation identifies measures which,

TABLE 6 **EROSION CONTROL MEASURES** (Adapted from Michigan Department of Natural Resources 1980)

		NAME	APPLICABILITY: Slopes	Streams and Waterways	Surface Drainageways	Enclosed Drainage (Inlet / Outlet)	Large Flat Surface Areas	Borrow and stockpile area	Adjacent Properties	COMMENTS	SUGGESTED AS A MINIMUM MEASURE ?
PROTECTION OF EXPOSED SURFACES	Vegetative	Seeding	•		•		•	•	•	Inexpensive and very effective. Stabilizes soil, thus minimizing erosion. Permits infiltration which reduces runoff volume. Should include prepared topsoil bed.	Yes
		Mulching	•			•	•			Used alone to protect exposed areas for short periods. Protects soil from rainsplash. Perserves soil moisture and protects germinating seed from temperature extremes	Yes
		Seeding with Mulch	•		•			•	•	Facilitates establishment of vegetative cover. Effective for Drainageways with low velocity. Easily installed on a small scale by inexperienced personnel Should include topsoil bed.	Yes
		Hydro-seeding	•				•	•	•	Effective on large areas. Mulch locking agent used to provide immediate protection until grass is rooted. Should include prepared topsoil bed.	Yes
		Sodding	•		•		•	•	•	Provides immediate protection. Can be used on steep slopes Easy to place Maybe repaired if damaged. Should include prepared topsoil bed.	Yes
	Non-vegetative	Rip-Rap / Rubble / Gabions	•	•	•					Used were vegetation not easily established. Effective for high velocities or concentrations Permits Infiltration. Dissipates energy of flow at system outlets.	
		Aggregate Cover					•			Stabilizes soil surface thus minimizing erosion. Permits construction traffic in adverse weather. May be used as part of permanent base construction of paved areas	Yes
		Paving	•				•			Protects areas which cannot otherwise be protected, but increases runoff volume and velocity. Irregular surface will help slow velocity.	
CONTROL OF RUNOFF		Selective Grading and Shaping	•				•	•	•	Water can be diverted to minimize erosion. Flatter slopes ease erosion problems	Yes
		Roughened Surface	•				•			Reduces velocity and Increases infiltration rates Collects sediment Holds water, seed and mulch better than smooth surfaces.	Yes
		Benches	•					•		Reduces runoff velocity by reducing effective slope length. Collects sediment. Provides access to slopes for seeding, mulching and maintenance.	Yes
		Rock / Strawbale Diversion Berm	•					•	•	Diverts water from vulnerable areas. Collects and directs water to prepared drainageways. May be placed as part of normal construction operation.	Yes
		Diversion Ditch	•					•	•	Collects and diverts water to reduce erosion potential. May be incorporated in permanent project drainage systems.	
		Energy Dissipator	•		•	•				Slows runoff velocity to non-erosive level. Permits sediment collection from runoff	

TABLE 7 SEDIMENT CONTROL MEASURES (Adopted from Michigan Department of Natural Resources 1980)

	NAME	Slopes	Streams and Waterways	Surface Drainageways	Enclosed Drainage (Inlet/Outlet)	Large Flat Surface Areas	Borrow and Stockpile Areas	Adjacent Properties	COMMENTS	SUGGESTED AS A MINIMUM MEASURE ?
FILTERING	Vegetative Buffer Strip	•	•					•	Slows runoff velocity. Filters sediment from runoff. Reduces volume of runoff on slopes.	Yes
	Filter Berm	•	•					•	Construction of gravel or stone. Intercepts and diverts runoff to stabilized areas or prepared drainage system. Slows runoff and collects sediment.	Yes
	Strawbale/Rock Filter				•			•	Inexpensive and easy to construct. Can be located as necessary to filter sediment from runoff. Strawbales may be used in conjunction with snow fence.	Yes
	Sod Filter				•				Inexpensive and easy to construct. Provides immediate protection. Protects areas around inlets from erosion.	Yes
	Brush Filter				•				Uses slash and logs from clearing operations. Can be covered and seeded rather than removed. Eliminates need for burning or removal of material from site.	Yes
IMPOUNDMENT	Strawbale/Sandbag/Excavated Sediment Trap		•	•					May be constructed of a variety of materials. Traps sediment and reduces velocity of flow. Can be cleaned and expanded as needed.	

if used alone, can be expected to provide only minimum protection. See Tables 6 and 7.

4.1.1 Degree of Control

Tables 6 and 7 indicate the types of control measures and their relative effectiveness in terms of "minimum" or otherwise.

The term "minimum", used in these guidelines, relates to the use of one individual control measure where a site evaluation shows negligible impact on the downstream water uses. For example, where a site has low erosion potential and the impact on downstream water uses is low, then from Table 7, Sediment Control Measures, the following would be considered "minimum" to practice "good housekeeping" measures:

- vegetative buffer strip to protect adjacent properties;
- strawbale filters to protect storm sewer inlets.

Where the evaluation shows the potential for greater impact on the downstream water uses, then more than one <u>single measure</u> for a <u>specific control purpose</u> will be required. The number of measures to be used will depend on the severity of potential impact on the downstream water uses.

Where temporary impoundment areas can be considered, the size of the facility should provide protection for the downstream environment against storms which, on the average, could occur once every two or five years.

The final test of the degree of control is whether the measures installed have the desired effect. This can only be determined through monitoring their effectiveness in the field (see section 5).

4.2 CONSTRUCTION PRACTICES AND SCHEDULING

During building activities on urban construction sites there are many areas of concern to the local municipality that occur frequently and are related to the erosion and sedimentation concerns. These include, but are not limited to, the following:

a) mud tracking from construction sites onto adjacent municipal streets;

b) silt and debris being washed into the existing convenience sewer system;

c) silt and debris being carried into receiving watercourses by rain and surface flows and through the sewer system; and

d) wind blown dust during dry summer months.

4.2.1 Construction Scheduling

To minimize the problems in a) to d) above, the following "good housekeeping" goals should be considered when preparing the construction schedule. While some may be impractical in certain

conditions, the designer should consider those which are appropriate, practical and cost effective.

1) Stock piles should be located away from watercourses and stabilized against erosion as soon as possible.

2) Where feasible for housing projects, and definitely for non-housing construction projects, all construction vehicles should leave the site at a designated point or points provided with a bed of non-erodible material (i.e. gravel) of sufficient length to ensure that a minimum of material (mud) is tracked off the site onto adjacent municipal streets. Where this becomes a major problem, a high pressure pump and hose installation may be used to provide a washdown facility for truck wheels.

3) When sewers have been installed and work is either suspended on the site for a period (i.e. winter) or house construction is in progress the manholes and catchbasins should be sealed (i.e. by installing plates under the covers). A temporary drainage system should be used with appropriate velocity controls (e.g. straw bales, retarding fences) and temporary storage areas for sediment control. This will ensure that sediment and debris do not get into the municipal sewer system. Care should be taken to ensure that the temporary drainage system does not flood adjacent properties.

4) Where on-site or downstream detention facilities are provided, use can be made of a quantity control facility (through the placing of temporary weirs or check-dams) for sediment control during construction. Therefore, all temporary and permanent detention facilities should be constructed <u>prior</u> to the installation of any services on the site or the commencement of earth moving operations. Similarly, any retention facility which will act as a sedimentation pond should be constructed <u>prior</u> to the installation of any other services on the site or the commencement of earth moving operations.

4.2.2 Construction Practices

During any construction period within an urban construction site, the following "good housekeeping" practices should be undertaken regardless of the soil erodibility and any other erosion and sediment control measures undertaken.

1) All catchbasins should be provided with sumps. The sumps should be inspected and cleaned frequently.
2) At the downstream end of the site, the last manhole on the storm sewer should have a sump which will retain any large debris. The sump can be cleaned out and filled in with concrete at the end of the project.
3) Small weirs should be built into the pipes at manholes

on the site that are near the outlet for the site drainage. This will provide impounding within the minor system and encourage settlement of the sediment being transported. Care should be taken when removing the weirs that the sediment is not washed into the municipal system.

4) Once the catchbasins have been installed and connected to the minor system, the basins in rear yards, ditches and low activity areas, should be buffered using straw bales on the upstream side. (For street catchbasins and high activity areas the straw bales do not provide adequate protection).

4.3 EROSION CONTROL MEASURES

A sound erosion and sediment control strategy should seek first to prevent the production of sediment through application of on-site erosion control measures. The two general approaches to achieving this goal are:

(a) the protection of exposed surfaces, and

(b) the control of runoff.

It should be emphasized that, where eroded material is moved around a site by stormwater, there is not necessarily any concern. The real problem occurs when sediment-laden flow leaves a site.

4.3.1 Protection of Exposed Surfaces

The protection of exposed surfaces from the erosive energy of rainsplash and overland flow should be the primary goal of the project designer when selecting appropriate control measures. It is commonly achieved through the use of temporary or permanent vegetative cover, mulching, paving, and chemical stabilization.

4.3.2 Control of Runoff

During construction it will not always be practical to provide surface cover for all disturbed areas. Commonly used methods for the protection of ground which must remain exposed include the modification of slope surface, the reduction of slope gradient, the control of velocity of flow, the diversion of flow around the affected area, and the upstream storage of potential runoff.

4.4 SEDIMENT CONTROL MEASURES

Although the preferred method of sediment control is the prevention of the initial erosion process, the production of some additional quantity of sediment on construction sites cannot be entirely eliminated. It is therefore important to complement those erosion control measures which have been selected with some form of effective sediment retention in order to prevent off-site

sedimentation damage. Generally this can be achieved by:(a) filtering the sediment-laden flow, or (b) impounding the sediment-laden flow, to allow the settling out of the sediment particles.

4.4.1 Filtering

Filtering can be applied to concentrated channel flow at the inlets of permanent or temporary drainage systems. This application requires careful maintenance, however, to ensure continued effectiveness since clogging can occur rapidly during periods of sustained high flow.
Filtering is most successful when sheet flows from a wide area are filtered along a line adjacent to the entrance to a drainage system or at the toe of slope of an embankment. Stream banks and the perimeter of regions of high erosion potential are typical sites where vegetative strips, stone filters and man-made fibre filters are employed to filter out sediment.

4.4.2 Impoundment

The impoundment of sediment laden flow in sediment traps lowers its internal energy and permits the settling of suspended sediment particles. This technique is normally applied to concentrated flow within the permanent or temporary drainage system of a site.

Traps may be formed through excavation, above ground embankments, or a combination of the two, and are commonly constructed of earth, stone, or strawbales. Correctly constructed and well maintained, sediment traps can be an effective means of minimizing the quantity of sediment which is transported away from the construction site.

Ideally, the sediment trap should be located within the site near the sediment source. Only the area exposed to erosion should drain into the trap. Roadside ditches and old drainage channels could also be used as sediment entrapment areas.

Depending on the runoff and available storage, temporary impoundment areas can be designed to store the entire runoff (and sediment) from the selected design event, (section 4.1.1), or discharge the flow after most of the sediment entering the facility has been deposited. For a detailed description of the design of temporary sedimentation basins, see references 11 and 12.

Temporary impounding areas that are created by the construction of significant embankments must be designed to Small Dam Standards. A qualified and experienced engineer should design the foundation and embankment, and provide inspection during and after construction. Similarly, the optimization of pond area and depth by a qualified engineer, can obtain maximum efficiency at least cost.

5. MONITORING AND MAINTENANCE

Once a combination of erosion and sediment control measures appropriate to the site has been selected, it is important that their effectiveness be monitored, the necessary maintenance be carried out, and there be a contingency plan for failure due to extreme runoff events. The success of the entire erosion and sediment control strategy will depend upon this, and its importance cannot be overemphasized. The monitoring will be the responsibility of the inspection team/review agency as defined in Section 7.

6. IMPLEMENTATION

The final step in the planning and design stage is the preparation of the erosion and sediment control documentation. All relevant information should be presented in the Stormwater Management Plan. Selection of the appropriate control measures should be based on the methodology outlined in this document. The existing Master Drainage Plans or Watershed Plans should identify special erosion or sediment control constraints, and the Stormwater Management Plan should indicate how the objectives and criteria outlined in these plans have been met.

6.1 FIRST PHASE STORMWATER MANAGEMENT PLAN

Developers applying for draft plan approval should acknowledge the fact that they intend to meet the objectives and conditions required to control erosion and sedimentation in accordance with the Master Drainage Plan and municipal policies and regulations. A preliminary erosion control package should consist of extracts from the Master Drainage Plan that relate to specific erosion and sedimentation criteria, constraints and objectives, along with a brief outline of the general strategy proposed for implementing the required erosion and sediment controls. This erosion control package, along with the evaluation summary material outlined in

section 3.3, comprise the material that should be included in a first phase Stormwater Management Plan.

6.2 FINAL STORMWATER MANAGEMENT PLAN

The final Stormwater Management Plan incorporates all the material in the first phase plan, plus an erosion and sediment control summary. The erosion and sediment control summary package should include details of the selected control measures, the areas in which they are to be used, the "good housekeeping" practices that are to be employed, and the procedures for monitoring and maintenance.

In summary, the final Stormwater Management Plan component that addresses erosion and sediment control should incorporate at least the following:

1) Large scale topographical map and detailed description sheets that indicate topography, overland flow routes, soils, drainage, existing sewer inlets, final grading, stock piles, zones of site erosion potential, stream dimensions and streamflow data, any special features, and the sensitivity of the downstream environment where flows could leave the site.
2) Details and extracts of objectives and conditions contained in any Master Drainage Plan, municipal policies and/or regulations.

3) Written description of the site, including evaluation for site erosion potential, downstream water uses, stream dimensions and streamflow data, special features not apparent from the map.

4) An indication of the degree of erosion and sediment control measures anticipated, based on the site erosion potential and downstream impacts.

5) Large scale map, as in (1), and detailed description sheets that indicate the location and extent of selected control measures, any temporary or permanent drainage systems, any stream diversions, storm sewer inlet locations, site entrance and exit locations.

6) Details of the basic "good housekeeping" practices to be implemented.

7) Procedures for monitoring and maintaining the erosion and sediment controls, including method of removing and disposing of sediment from any sediment traps.

8) Details of contingency plan for failure of control elements during extreme runoff events, when impacts on water are severe.

NOTE: Items 1 to 4, first phase Stormwater Management Plan

Items 1 to 8, final Stormwater Management Plan

7. INSPECTION AND REVIEW

The local municipality should be responsible for inspecting and reviewing the erosion and sediment control measures on their own construction projects, and on building sites where they issue building permits.

For subdivisions, private developments and other government agency projects that require municipal approval, the local municipality, or its agent, should be responsible for inspecting and reviewing the erosion and sediment control measures.

Projects in natural watercourses, rivers and along lake shores will usually require permits from other agencies or authorities such as the Ministry of Natural Resources and the local Conservation Authority. While erosion and sediment controls will be required, the responsibility of inspection and review will lie with the approving agency. The requirements for erosion and sediment control measures should be in accordance with those of the approving agency.

On projects where the local municipality is responsible for inspecting and reviewing erosion and sediment control measures, it should check that the controls being used are adequate, and that effective maintenance of the controls is being carried out after the facilities are constructed.

After a Master Drainage Plan has been adopted by a Council, with appropriate technical manuals or guidelines referenced,all

construction work carried out within the drainage area of that Master Drainage Plan should be in accordance with the recommendations of the Plan. Municipal staff, or their agents, should check developer Stormwater Management Plans, design drawings of their own projects, and drawings of other agency's projects to ensure compliance with the erosion and sediment requirements of the Master Drainage Plan.

If a Master Drainage Plan has not been prepared, the material contained in these guidelines will provide adequate detail for carrying out an erosion and sediment control evaluation. The control measures chosen should include the "good housekeeping" practices and other measures appropriate for the potential impact that the project might have on the downstream water uses. Where necessary, other agencies can be contacted for their input regarding any specific concerns they might have.

SECTION B

STANDARDS AND SPECIFICATIONS

FOR

EROSION CONTROL MEASURES

E.C.S.1

SEEDING

INTRODUCTION

Seeding refers to the establishment of plant cover on disturbed areas by applying seeds of annual or perennial plants. The seeds are drilled or broadcast, either mechanically or by hand, depending upon site conditions. Grasses and legumes are commonly used in seed mixtures. Fertilizer and mulch are often applied immediately after seeding. Seeding can provide long-term, temporary or permanent stabilization of disturbed areas. The cost of seeding a disturbed area is relatively low and its effectiveness on a long-term basis is quite high.

APPLICATION

The use of seeding as an erosion control measure can only be undertaken during or immediately preceeding the growing season. Seeding is used on sites where long-term control is required over a time period of approximately six months. Seeding will not provide an immediate plant cover and bare soil will persist until plants have developed.

Seeding is most appropriate in flat areas and on slopes less than

3:1, where equipment accessibility is not limited. Seed mixtures must be selected to suit the site conditions. Factors affecting plant growth include climate, soils, topography, land use and planting season. Site conditions will determine the application rate and the mixture of seeds used.

DESCRIPTION

Grasses and legumes are generally used in seed mixtures. Grasses are highly adaptable to various site conditions and provide a dense and lasting ground cover. The fibrous root system of grasses anchors the soil and allows surface water to infiltrate more rapidly.

Legumes are commonly used in combination with various grasses. They are important because of their ability to fix nitrogen and to make it available for plant growth. Some species of legumes have large tap roots that enhance both soil stabilization and infiltration.

INSTALLATION

Site Preparation

To establish a good catch of vegetation, proper seedbed preparation is very important. The soil must be modified to

provide the optimum environment for seed germination and seedling growth. Seedbed preparation includes surface roughening and fertilizing.

The surface soil must be loose enough for water infiltration and root penetration. Top layers of compacted soil should be loosened by discing, raking or other acceptable means prior to seeding.

A soil test should be completed to determine the nutrient and pH requirements. Soil tests may be conducted in the field using an appropriate soil testing kit, however, it is preferable to have the soil tested by a soil testing laboratory. The soil sample must be taken from the top 10 cm of the final graded substrate including any additional incorporated topsoil. The final pH of the soil should range from 6 to 7. If a soil test is not feasible, fertilizer of ratio 1:4:4 should be applied at a rate of .45 to .68 kg of nitrogen/100 m^2 .

Seeding

A seed drill or brillion seeder may be used under conditions of adequate moisture on areas suitable for the operation of machinery. Mulch is not mandatory if the seed is covered with soil or a seed drill is used. This method uses a low seeding rate and will give the best germination.

In broadcast seeding, seed is applied to the soil surface and not cultivated into the soil. The seeding rate is higher than in

seed drilling. A mulch is necessary to protect the seed and prevent it from being washed or blown away during germination. The mulch is applied after seed and fertilizer application (see Standards and Specifications for "Mulching").

The success of seeding operations will depend on adequate knowledge of site conditions including soil drainage, texture and pH. Whenever possible, expert advice should be sought concerning site conditions.

MAINTENANCE

Seeded areas should be maintained according to location and plan. High maintenance areas will be mowed frequently, irrigated, fertilized, and the weeds intensively controlled.

Low maintenance areas will receive proportionally less maintenance input.

However, even low maintenance areas should be watered and fertilized to ensure that the seeding is effective and a stand of vegetation is established. The first year after seeding is critical. Water application rates should be heavy but controlled to prevent runoff.

Small areas of failure must be reseeded promptly. If the stand has less than 40% cover, the choice of plant material and quantities of soil amendments should be re-evaluated.

SPECIFICATIONS

1. Canada No.1 seed shall be used for all seeding operations. Seed should be tested within six months immediately preceeding the date of sowing.
2. Seed application rates will be dictated by site conditions, climate, soils, topography, land use, planting season, and seed types. In general, seeding rates shall be at least 15 kg/ha on good agricultural soil. In areas where seed catch may be difficult due to poor nutrient status in the soil, seeding rates shall be at least 20 kg/ha.
3. When using a seed drill or brillion seeder, grasses and legumes shall not be planted more than 1 cm deep.
4. Bacterial inoculants must be used when seeding with legumes. A specific inoculant shall be used for the legume being seeded in accordance with supplier's recommendations for specific products.
5. Fertilizer, in lieu of a soil test, shall be 1:4:4 fertilizer. It shall be applied at a rate of 45 to 68 kg of nitrogen/ha depending upon site conditions.
6. Seeding shall occur during periods when germination can be guaranteed and plants have sufficient time to become established before the end of the growing season (i.e. May 15 - June 1 and/or August 15 - September 15, plus or

minus). Seeding should not occur after the 50 per cent frost probability date for the site.

7. When broadcasting seed, mulching is required.
8. Mulching of the exposed soil is required if seeding is carried out after the date specified in which fall. seeding should not be carried out.

E.C.S.2

MULCHING

INTRODUCTION

Mulching refers to the application of organic material or other suitable substances to the soil surface to conserve a desirable soil property or to promote plant growth. Mulches conserve soil moisture, prevent surface compaction; reduce runoff and surface erosion, control weeds and help establish plant cover.

APPLICATION

Mulching can be used to provide both short and long-term erosion control. Mulches may be used in areas that are graded or not graded, with or without the use of plant material. They may be applied immediately following broadcast seeding (or planting), or with seed application to provide suitable soil conditions for optimal plant growth. Mulching may also be used for long-term erosion control in the absence of plant material or seeding.
The choice of materials for mulching will be based on the type of soil to be protected, site conditions, season, costs, availability of materials, and the availability of labour and equipment. Non-biodegradable mulches should not be used in areas where they may become a source of litter.

DESCRIPTION

Organic mulches include straw, raw wood fibre, peat moss, wood chips, bark, pine needles, compost and verdyol. Chemical mulches include a wide range of synthetic spray-on materials marketed to stabilize and protect the soil surface. These can be emulsions or dispersions of vinyl compounds, asphalt, rubber or other substances which are mixed with water before application. Chemical mulches may be used to bind other mulches or with wood fibre in a hydroseed slurry.

Organic Mulches

a) Straw - This is the stalks or stems of small grains (mostly wheat) after drying and threshing. Straw is packed in bales and is available in bulk quantities. It should be relatively free of weeds. Loose straw is very susceptible to windblow. When tacked down, it is highly suitable for promoting good grass cover quickly. It may, however, be a fire hazard.

b) Raw Wood Fibre - This is a conglomeration of cellulose fibres 4 mm or longer extracted from wood. These fibres usually require a soil binder. Wood fibre is used in hydroseeding operations where it is applied as part of a

slurry. It should not be used for erosion control during hot periods in the summer or for late fall seeding unless it is used in association with another suitable mulch. It may be sprayed on top of an installed net and is well suited for tacking straw mulch on steep slopes.

c) Peat Moss - This is material consisting of partly decomposed mosses accumulated under conditions of excessive moisture. It is usually available dried and compressed. It should be free from coarse material. Peat moss is a useful soil conditioner when mixed with the soil. When dry and placed on top of the soil, it may be susceptible to windblow.

d) Wood Chips - These are small, thin pieces of sliced wood slabs and edgings produced as a by-product in sawmills. Wood chips decompose slowly. They are suitable around individual plants and for areas that will not be closely mowed. Wood chips are resistant to windblow.

e) Bark Chips, Shredded Bark - These are slices and scrapings of tree bark produced as a by-product of timber processing. Suitable for areas that will not be closely mowed, they have a good moisture holding capacity and are resistant to windblow.

f) Pine Needles - These leaves of pine trees should be air dried and free from coarse material. They decompose

slowly and are suitable for use with plants that prefer acid soils. Pine needles are resistant to windblow.

g) Compost of Straw Manure - These are organic residues and straw that have been piled and allowed to undergo biological decomposition until relatively stable. Compost or straw manure should be well shredded, free from excessively coarse material and not wet. It has good moisture holding capacity and is very suitable as a soil amendment. It should be resistant to windblow when moist.

h) Verdyol - Verdyol is a product made from cotton waste, recycled newspaper and specially treated straw and hay. It does not need a binder and is primarily used in hydroseeding.

Chemical Mulches

a) Aerospray 52 Binder - This is a non-toxic,non-phytotoxic mulch that can be applied using any non-air entraining equipment for applying liquid fertilizers, asphalt emulsions and water. The mulch has a pH of 8-9 and should not be used with acid-loving plants.

b) Aquatain - This is a water dispersible, non-toxic, non-flammable mulch that is mixed with water and applied using a hydroseeder and other equipment designed for

asphalt emulsions or water.

c) Curasol EA - This is a non-toxic, non-phytotoxic, water dispersible mulch with a pH of 4-5. It may be applied using spraying equipment for asphalt emulsions or water.

d) DCA-70 - This is a non-flammable, non-toxic, non-phytotoxic, water dispersible mulch with a pH of 4-6. It can be applied using sprayers designed for asphalt emulsions or water.

e) Petroset SB - This is a non-flammable, non-toxic, free flowing and water dispersible mulch that can be applied with spraying equipment designed for asphalt emulsions or water.

f) Terra Tack - This is a water dispersible mulch that can be applied during hydroseeding or in a powder form using standard hopper spreaders used for applying fertilizers or lime.

INSTALLATION

Site grading and required sedimentation control practices should be undertaken prior to mulching. Surface roughening, fertilizer application and liming should occur prior to mulching if seeding is included (see Standards and Specifications for "Seeding").

The method of application of mulches depends on the type of mulch being used. Organic mulches can be applied by hand or machine. Chemical mulches are usually applied with sprayers designed for asphalt emulsions or water.

With most mulches, steps must be taken to anchor the mulch or bind it to the soil. Methods include the use of chemical binders, asphalt spray, mulch netting, peg and twine and punching or tracking.

Chemical binders are usually the same products that are used as chemical mulches (see Standard Specifications for "Chemical Stabilization"). They can be used in a hydroseeder or applied separately.

Asphalt spray may be used with straw, wood chips or compost. Asphalt must be thin enough to be blown from spray equipment.

Mulch netting made from jute, wood fibre or plastic (see Standards and Specifications for "Nets and Mats") may be used with many organic mulches. Netting is often used on critical areas such as creek banks at water crossings. The installation of netting is usually labour intensive.

Peg and twine is also labour intensive but suitable for small areas. Wooden pegs are placed every 120 cm in all directions. Twine is stretched between the pegs in a criss-cross within a square pattern.

Punching is suitable for straw mulch. The straw is cut into the soil surface with a square edge spade in contour rows. Tracking

involves driving a bulldozer over the straw. The cleats of the bulldozer cut the straw into the soil surface.

MAINTENANCE

All mulches should be inspected periodically, especially after rain storms, to check for erosion and decomposition. Where needed, additional mulch should be applied.

SPECIFICATIONS

1. Application rates for mulches are as follows:

Straw	- 3,000 to 4,500 kg/ha
Raw wood fibre	- 1,000 to 2,000 kg/ha
Peat moss	- 10 to 30 m^3/ha
Wood chips	- 9,000 to 13,000 kg/ha
Bark chips, shredded bark	- 90 to 140 m^3/ha
Pine needles	- 4,000 to 5,000 kg/ha
Compost or straw manure	- 18,000 to 22,000 kg/ha
Verdyol	- 1,000 to 1,500 kg/ha
Chemical mulches	- follow manufacturer's recommendation

2. If applying straw by hand, divide the areas to be mulched into 100 m sections and place the straw in each section to facilitate uniform distribution.

3. Chemical mulches shall be applied at manufacturer's recommended rates. They shall not be applied during very hot periods or during periods of frost.
4. When anchoring mulch with an asphalt emulsion, apply asphalt at 5400 l/ha. Do not use heavier applications as it may cause the straw to "perch" over rills.

E.C.S.3

HYDROSEEDING

INTRODUCTION

Hydroseeding refers to the establishment of plant cover on disturbed areas by applying in one operation seeds of annual and perennial plants along with fertilizer, mulch, soil adhesives and water. Seed, fertilizer, mulch, soil adhesives and water are mixed together in a holding tank to form a slurry. The slurry is held in suspension by continuous agitation. Using a high pressure pump, the mixture is sprayed on the area to be revegetated.

APPLICATION

Hydroseeding may be used to provide soil stabilization in disturbed areas where it is economical, adaptable to site conditions, and allows selection of the most appropriate plant materials. Hydroseeding enables the quick revegetation of very steep rocky or gravelly slopes where revegetation by any other method would be extremely difficult and expensive. It can also be used in areas where conventional methods such as broadcast seeding, seed drilling or sodding are applied.

The site must be accessible to the hydroseeding unit (mounted on a

truck). The hoses from the hydroseeding unit have a maximum range of about 150 m.

DESCRIPTION

Seed, fertilizer and mulch should be carefully selected to conform to site conditions. Soil characteristics, climatic conditions, topography, land use and planting season should be considered when determining materials to be used in hydroseeding. The required amount of materials will again depend upon site conditions. If needed, soil stabilizing materials can be incorporated into the slurry.

Since the success of hydroseeding operations will depend on adequate knowledge of site conditions (including soil drainage, texture and pH) expert advice should be sought concerning methods for different circumstances.

INSTALLATION

Since hydroseeding often is used to revegetate hard to reach areas (i.e. steep slopes, dry sites with little or no topsoil), site preparation is not always possible. In accessible areas, however, surface roughening may be very advantageous prior to hydroseeding.

The surface soil must be loose enough for water infiltration and root penetration. When the area to be hydroseeded is compacted, the soil surface should be loosened by discing, raking or other acceptable means prior to hydroseeding.

Seed, fertilizer, soil adhesives, mulch and water should be mixed together in the holding tank of the hydroseeding unit to form a slurry. The filling capacity of the holding tank usually varies between 440 and 660 litres. The slurry must be agitated continuously throughout the entire spraying process to ensure consistency. A special heavy pump produces the required pressure to spray the mix on the area to be revegetated. The mobile spray gun of the hydroseeding unit has a range of about 60 m. Hoses from the hydroseeding unit have a maximum range of about 150 m.

Hydroseeding is a relatively fast operation since seed, mulch and fertilizer are applied in one step. Between 4,000 and 20,000 m^2 can be hydroseeded by one unit each day, depending on site conditions.

MAINTENANCE

During the first year after seeding, it is necessary to water and fertilize according to weather and soil conditions. Water application rates should be heavy but controlled to prevent

runoff. Fertilizer will need to be applied only if it was not adequate at the time of seeding.

Small areas of failure must be reseeded promptly. If large areas of failure occur, the method of hydroseeding should be re-evaluated.

SPECIFICATIONS

1. Seed, mulch, and fertilizer application rates will depend on site conditions (see Standards and Specifications for "Seeding" and "Mulching").
2. If seeding with legumes, the bacterial inoculant will need to be applied at 4 times the normal rate.
3. The slurry shall be applied to the area to be revegetated in a layer 0.2 to 2 cm thick. In rocky areas and areas with little topsoil, the layer may be thicker. If more than one application is necessary the first layer shall be dried or settled before the second layer is applied.
4. Hydroseeding shall not be permitted during periods of heavy rain, strong winds or frost.

E.C.S.4

SODDING

INTRODUCTION

Sodding refers to the use of permanent grass sod to cover and stabilize disturbed areas. It is used to rapidly establish plant cover in areas where complete cover of the soil surface is required without delay or where seeding may not be practical (i.e. drainage ways) to establish grass. The use of sod is generally much more expensive than seed, however, it has an immediate effect.

APPLICATION

Sod may be used to protect graded surfaces from water and wind erosion where adequate topsoil or fertilizer and water can be provided. It is best used for areas that are steep or require immediate protection, or at locations where aesthetic considerations are a priority. Sod may be maintained or left unmanaged.

DESCRIPTION

Sod may be Nursery or Field Sod. It may be composed of one or

more species/cultivars of grasses and may contain associated plants such as legumes. In Ontario, Nursery Sod is composed of at least 50% Kentucky Bluegrass cultivars.

Field Sod is sod not specifically produced for sale as turf and is generally not certified as to composition or degree of weed infestation.

INSTALLATION

Site Preparation

Sod must be laid on fine graded areas where close and complete contact between the sod roots and the soil/substrate surface can be maintained. The surface must be clear of debris, stones, plant remains, trash and other objects of greater than 5 cm diameter. The surface must be graded smooth and be free of air or water pockets.

Before sod is laid, a soil test should be completed to determine the nutrient and pH requirements. Soil tests may be conducted in the field using an appropriate soil testing kit, however, it is preferable to have the soil tested by a soil testing laboratory. The soil tested consists of a sample from the top 10 cm of the final graded substrate including any additional incorporated topsoil.

Where a soil test is not feasible, fertilizer of ratio 1:4:4

should be applied at a rate of .45 to .68 kg of nitrogen/100 m^2. Soil amendments must be incorporated into the top 7-15 cm of the soil/substrate surface using normal agricultural tillage practices. The site must be fertilized not more than 48 hours before the sod is laid.

Sod should not be laid on sites without topsoil. Topsoil should be spread evenly across the site to a depth of 7-15 cm and incorporated into the surface of the substrate by discing or cultivating.

Installation

Successful installation requires the use of freshly cut healthy sod. Sod must not be laid on frozen ground surfaces. During dry, hot periods, the ground surface must be cooled by irrigation before the sod is laid. Sod must be rolled or tamped firmly to ensure good soil contact. Freshly installed sod must be irrigated to moisten soil to a minimum depth of 10 cm.

The installation of sod on steep or potentially unstable slopes requires that sod strips be placed with the long axis perpendicular to the fall of the slope. Sod must be placed such that all joints form an interlocking pattern of strips across the slope. Each sod strip must be pegged with a suitable wooden stake or metal staple 15-25 cm long inserted flush with the sod surface, using one stake or staple on centre every 60 cm (Figure 3).

MAINTENANCE

Sod should be maintained by fertilizing, irrigating, mowing and weed control depending on location and plan. Sod shall be irrigated to maintain field capacity moisture levels to a minimum depth of 10 cm for the first week after installation. It should be fertilized as indicated by the soil test or the following schedule may be used:

Nutrient Rate

($kg/10\ m^2$)

Time	Nitrogen	Phosphorus	Potassium
Early Spring	0.5	0.25	0.25
Early Summer	0.5	-	-
Mid-Summer	0.5	-	-
Early Fall	0.5	0.25	0.25

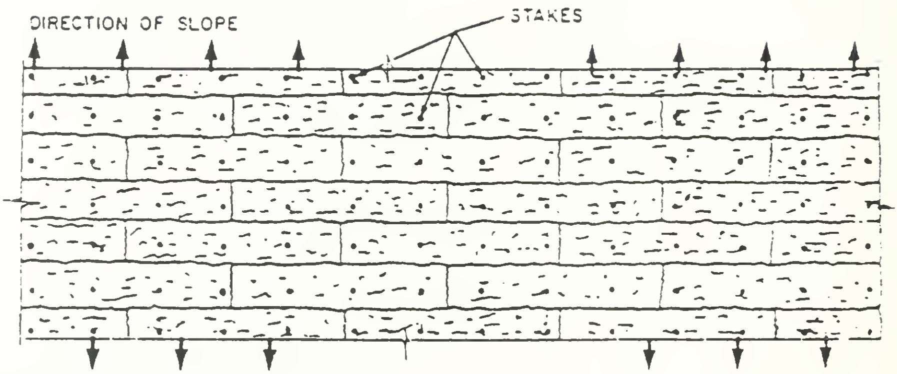
Sod that is to be maintained by mowing shall not be mowed within two weeks after installation. It shall be mowed systematically throughout the growing season beginning in the spring after the grass is 6 to 8 cm high and ceasing when cold weather in the autumn restricts growth. No more than 35 to 40 per cent of the shoot shall be removed at any one cutting; turf grass is maintained best at between 3 to 7 cm in shoot height. Grass clippings should remain on the sod after mowing unless they

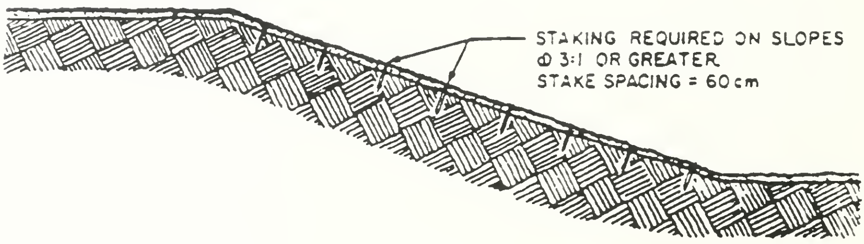
accumulate at greater than 1 cm depth when they should be removed.

Weeds may be controlled in sod that is to be moved or left unmanaged according to accepted horticultural practices.

FIGURE 3

SODDING





SPECIFICATIONS

Nursery sod or field sod may be used to control erosion:

Nursery Sod

1. If nursery sod is used, it shall meet the requirements of the Ontario Sod Growers Association for No.1, Kentucky Bluegrass cultivars. It shall be cut from a stand two years of age and shall be weed-free (no more than two broad-leaved weeds, or ten other weeds/40 m^2).
2. The mowing height limit shall be 3.5 to 6.5 cm.
3. The soil portion of the sod shall not exceed 4.0 cm.
4. Sod shall be cut from fertile, loamy soil, be well rooted, disease-free and of uniform texture. It should not be lifted during excessively hot, dry periods and should be moist enough to remain viable during storage, transport and installation.
5. Sod shall be cut to standard dimensions or as required by the planting plan. (Standard dimensions are approximately 40 cm wide by 200 cm long to form 0.8 m^2 coverage).
6. Sod shall be rolled unless otherwise specified and shall be in a condition such that it may be handled and

installed without tearing or breaking.

7. Sod shall be harvested within 36 hours preceding installation.

E.C.S.5

RIP-RAP

Rip-rap made up of large loose angular stones will provide a durable erosion resistant ground cover. The purpose of placing rip-rap is:

i) to protect the soil surface from erosive forces;

ii) to slow the velocity of runoff; and

iii) to stabilize slopes.

Stone rip-rap is durable, heavy and flexible and is the most popular material used in constructing revetments. The popularity is due to the fact that rip-raps are flexible as the stone rip-rap adjusts to changes resulting from erosion beneath the stone and the rough surface of the stones dissipate part of the energy of the flowing water. The most common locations for rip-rap are stream channel banks, slopes of dikes, inlet and outlet structures carrying water and bridge abutments.

Where erosion potential is high, rip-rap should be placed as soon as possible after the soil has been disturbed. For inlet or outlet protection, rip-rap should be placed before the flow has an opportunity to create erosion.

Rip-rap shall be made up of a graded mixture in such a way that 50 per cent of the mixture by weight shall be larger than the d50 size selected by the designer. The largest size shall be 1-1/2 times the d50 size while the smallest size shall be approximately

2 cm. The designer should be aware that smaller sizes of rip-rap are more vulnerable to vandalism.

The minimum thickness of the rip-rap layer shall be 1-1/2 times the maximum stone diameter, but not less than 15 cm. Refer to M.T.C. Specification for Rip Rap, form 511 (metric).

For flow stabilization projects, the angle of repose of the rip-rap stones shall be greater than the slope to be protected. A practical maximum slope for rip-rap is 2:1.

Filter blankets which are placed between rip-rap and the soil to be protected are made up of gravel or man-made filter cloth. The function of the filter layer is to:

i) separate the soil from the rip-rap;

ii) redistribute the forces acting on the soil;

iii) provide drainage facilities.

The erosive force of flowing water is greater in bends than in straight channels, therefore rip-rap sizes for bends should be larger.

E.C.S.6

AGGREGATE COVER

INTRODUCTION

Aggregate refers to the use of crushed stone or gravel applied directly to the soil surface. Aggregate secures the soil, reduces erosion and provides a continuous all-weather cover.

APPLICATION

Aggregate as a cover may be used to stabilize soil surfaces and to reduce erosion by construction traffic (especially during wet weather), in wet areas or on slopes. It is used to stabilize large flat disturbed areas where the site is being prepared for paving or where the use of vegetation is not feasible (such as on a temporary roadway parking area). The use of aggregate to reduce erosion of permanent roadways during construction helps to minimize the amount of regrading necessary between the initial grading and the permanent stabilization.

A granular blanket of aggregate placed evenly over the surface of slopes will stabilize erosive soils. It is particularly suitable for areas where ground water emerges through the surface soil. The granular blanket of aggregate provides a stable, free draining slope material.

INSTALLATION

When aggregate is used as a means of erosion control on temporary access roads and parking areas, the roadbed or parking area surface shall be cleared of all objectionable material, including all vegetation and roots. Grades should be sufficient to provide adequate drainage. The contour of the natural terrain should be followed to the extent possible. For quick stabilization, aggregate should be applied immediately after the sites have received their initial grading.

Where aggregate is used as a means of slope erosion control, the erosive soils must be prepared and smoothed so that the stones will remain in place. Aggregate must be placed evenly over the surface to provide a stable, free draining slope material.

MAINTENANCE

Periodic improvement with new gravel, usually a top dressing, may be required on temporary and permanent roadways and on parking areas. Slopes should be checked for washouts after storms. Any damage must be quickly repaired.

SPECIFICATIONS

1. On temporary roadways and parking areas, a 14 cm to 18 cm course of Granular A or 16 mm crushed aggregates Types A and B shall be applied to the site immediately after grading.
2. Granular A and 16 mm crushed aggregates Types A and B shall be crushed rock or gravel composed of hard, durable, uncoated, cubical fragments.
3. Granular A and 16 mm crushed aggregates Types A and B composed of crushed slag produced from iron blast furnace slag or blended nickel slag shall not be used as a means of erosion control in or near a watercourse or on steep or wet areas, including slopes, because of the possibility of heavy metal contamination.
4. On slopes of erosive soils, the granular blanket shall be 3 cm to 5 cm thick and shall be composed of material such as a Granular Course Class "B" aggregate.
5. Granular "B" aggregate shall be composed of clean, hard, durable uncoated particles.
6. Granular "B" aggregate shall not be composed of mine waste, iron blast furnace slag, or blended nickel slag or clinkers because of possibility of contamination of the ground water by materials contained in the aggregate.

E.C.S.7

CHEMICAL STABILIZATION

INTRODUCTION

Chemical stabilization refers to the use of chemical substances which change the properties of the soil surface, generally by aggregating the finer soil particles. Soil stabilizers, of a chemical nature, are used in place of temporary mulch materials and in combination with mulch materials to act as both a mulch tack and a soil binder.

APPLICATION

Chemical soil stabilizers are used to protect from erosion exposed soil slopes not subject to traffic during the temporary establishment of a seedbed. Chemical stabilizers can also be used to provide temporary erosion protection before revegetation is started. It is advantageous to use chemical soil stabilizers in areas where the use of vegetation as a soil stabilizer is not possible.

The liquids are generally applied to recently exposed soil to increase cohesion of the surface. This helps the development of a permanent vegetative cover by reducing erosion and retarding drying.

Chemical soil stabilizers generally work best on a dry, highly permeable soil, or on soils already in place which are subject to sheet flow rather than concentrated flow.

Long-term protection is not achieved by chemical soil stabilizers. As a result, this method of stabilizing soils should be viewed as being only temporary. However, on light, sandy substrates, an improvement of the soil nutrient and water supply can be achieved through the use of hydrosilicates.

DESCRIPTION

A long lasting effect of up to two years can be obtained if the material is repeatedly sprayed, higher concentrations of the material are used, or if the granules are worked into the soil. However, revegetation of these areas may no longer be possible as the seeds may be prevented from germinating.

In areas which suffer from frost, crust forming stabilizers such as bitumen cannot be used as cracks develop and the surface breaks into pieces.

TABLE 8

CHEMICAL SOIL STABILIZERS

Type	Characteristics
Alginate	paste-like emulsion or granulate produced from sea algae and consisting largely of natural carbohydrates with associated minerals added.
Aquatain	water dispersible, non-toxic.
Asphalt Sprays	available as an asphalt emulsion or as a liquid asphalt.
Bitumen	thick-flowing undilutable emulsion or a cold emulsion, 50% dilutable with water.
DCA-70	water dispersible, non-toxic, non-phytotoxic.
Hydrosilicates Methylcellulose	gel-like elastic film in a powder form or as a water based emulsion.
Plastic Emulsion	usually a liquid which can be diluted with water, producing a thin film to cover the surface of the soil.
Polyvinyl alcohol	an emulsion with water.

INSTALLATION

Application of the liquids is usually conducted with standard hydroseeding equipment or coarse pressure spraying nozzles. Asphalt sprays and rubber emulsions can be applied using non-air entraining equipment.

It is recommended that a representative plot be tested with the chemical soil stabilizers so that the correct mixture and application rate of chemicals and water can be selected.

MAINTENANCE

The period of effectiveness lasts from a few weeks to half a a year. It will be longer where hydrosilicates are used and where granules are worked into the soil. Repetitive spraying will prolong the effect.

SPECIFICATIONS

TABLE 9

APPLICATION RATES OF CHEMICAL SOIL STABILIZERS

Chemical Soil Stabilizer	Application Rate
Alginates	5.56 grams in 2.25 l of water/m^2
Terratack II	
Terratack III	
Aquatain	1 part Aquatain to 5.5 parts water
Asphalt Sprays	
asphalt emulsion	0.22 l/m^2
liquid asphalt	0.55 l/m^2
Bitumen	0.1 to 1 kg/m^2
DCA-70	1 part DCA-70 to 1 part clean water; 2.7 l or more/m^2
Hydrosillicates	
Minimum Requirements	14 g/m^2
Sodium hydroxide	100 g/m^2
Benonite	400 g/m^2
Rock phosphate	400 g/m^2
Hydrosillicate	
Methylcellulose	
Minimum Requirement	50 g/m^2
Plastic Emulsion	
Minimum Requirements	Dilution from 1:10 to 1:100
Curasol AE	60 g/m^2
Curasol AK	50 g/m^2
Curasol AH	100 g/m^2
Polyvinylacholos	Dilution from 1:9 to 1:40
Elvanol	2 l/m^2

E.C.S.8

NETS AND MATTING

INTRODUCTION

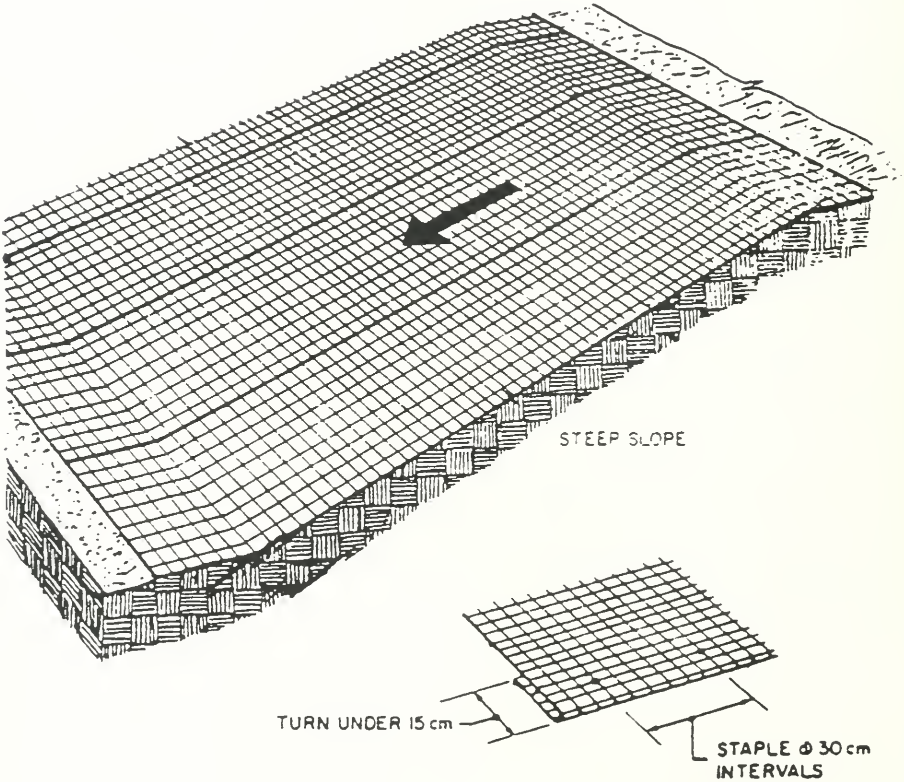
Nets and matting are placed on the ground surface to stabilize the soil. They may also be used in combination with mulch materials. Generally, nets and mats are inexpensive, easily placed and not subject to wind blow providing they are properly anchored.

APPLICATION

Mats used without other stabilization techniques are suitable for use on level areas, in waterways, or on slopes. Primary use is on steep slopes and where newly established vegetation in swales and channels requires protection. Matting is used in areas where soil moisture is high, as soil moisture is not retained by the nets or mats. Mats can also be applied to areas where a high velocity of runoff tends to scour newly established or establishing vegetation. When used in a combination with mulch materials, mats act as an anchor binding the mulch material and preventing wind blow.

FIGURE 4

NETTING AND MATTING



DESCRIPTION

Net and mat materials include jute, twisted paper mesh, fiberglass, cotton, finely woven plastics, excelsior and woven metal wire. Staples, usually made of plain iron wire, are used to hold the mats in place.

INSTALLATION

Obtaining a firm, continuous contact between the soil surface and the mat is the most important aspect to consider during installation (Figure 4). Failure to maintain that contact renders the process useless and results in further erosion.

The area which is to be protected should be shaped or graded to provide a good surface for mat placement. Material which will prevent a good contact between the mat and the soil surface, such as rocks or debris larger than 4.5 cm in diameter, must be removed.

The mat should be laid from the top of the slope and allowed to roll down the slope. It should be placed loosely over the soil. Stretching of the mat should be avoided.

When the mat has been stapled and the seed has been applied, the mat should be rolled to make certain there is good contact between the mat and the soil.

MAINTENANCE

The protected area should be regularly inspected, especially after a rainfail, to check for mat separation or breakage. If breakage does occur, any damage should be repaired immediately. The temporary inspection should continue until the grasses have become well established. After a year, a top dressing of fertilizer may be applied to improve the vegetative covering and assist the degradation of the temporary matting.

SPECIFICATIONS

1. In areas where the soil is highly erodible or when mulching is carried out in summer or in late fall, mats shall only be used with an organic mulch.
2. The mats shall be installed over the mulch, except if the mulch is wood fibre. Wood fibre may be applied over the installed mat.
3. Excelsior matting may be used at all times of the year and may be applied alone on erodible soils, as they are considered to be protective mulches.
4. The ends of the mat shall be buried in a trench at least 15 cm deep, at the top of the slope. Earth shall be tamped over the anchor slot and staples shall be applied every 30 cm across the top and every 1 m along the mat edge.

5. The adjacent edges of two adjoining mats shall be overlapped 10 cm and stapled together.
6. Staples shall be applied at 1 m intervals down the centre of the mat.
7. In areas where strips are to be joined, a new roll of mat shall be inserted into an anchor slot, in the same manner as the up-slope end. The end of the previous mat shall overlap the new mat by 50 cm and then it shall be turned under 15 cm.
8. The staples shall be applied every 30 cm across the end of the roll at the end of the turned-under mat, just below the trench or anchor slot.
9. At the bottom of the slope, the mat shall be led out to a level area before it is anchored and the ends turned under 15 cm. Staples shall be applied every 30 cm across the end.
10. Erosion check slots shall be made on areas which are highly erodible or where the slopes exceed 4:1. A fold of mat shall be inserted into a trench or anchor slot every 5 m and tamped firmly. Staples shall be applied every 1 m across the downstream portion of the mat.
11. Staples will be made of 4 mm diameter, or heavier, plain iron wire and will be at least 15 cm in length.

E.C.S.9

TREES AND SHRUBS

INTRODUCTION

Trees and shrubs are forms of vegetation that can be used to cover and stabilize disturbed areas as well as to prevent the initiation of erosion. They form a canopy above the ground and thus protect the soil surface from the full impact of falling rain and high winds. When the stand is well established a layer of litter also covers the ground and, with decomposition, increases the soil absorption capacity. Trees, particularly evergreens, will slow down the melting of snow and runoff in the spring. The roots of shrubs and trees, however, are not as effective as thick grass roots in holding the topsoil against high velocity surface runoff.

Herbaceous vegetation provides erosion control more quickly. Time is needed to establish a good stand of woody species, during which competing herbaceous vegetation must be controlled.

Planting of very large woody stock is expensive and not necessarily effective sooner than planting of smaller and better-balanced stock. Hand planting of large and difficult areas is also expensive. Maintenance of established stands, however, is inexpensive.

APPLICATION

Trees and shrubs may be used to protect graded or cleared areas from water and wind erosion where adequate topsoil is available and where a permanent vegetative cover other than that of herbaceous species is wanted. They are best used on steep or rocky slopes where mowing is not feasible, in shady areas where herbaceous species experience difficulty, and where forestry, landscaping and wildlife features are desired.

Trees and shrubs will help to control foot traffic, will not require as much maintenance as mowed lawns, and will be more attractive than unmowed grass cover. However, these plants cannot prevent soil slippage on a soil that is not stable due to its texture, structure, water movement or excessive slope.

DESCRIPTION

Species Selection

A wide range of trees and shrubs can be grown in Ontario. While cost and availability are important, the choice of species should be based on a range of criteria including winter hardiness, tolerance to soil and air conditions, and suitability for the purpose of planting.

In general, the choice of species narrows as the planting site becomes drier, less fertile and colder. Since erosion prone soils are often dry and infertile as well as unstable, the site should

be carefully inspected before the final selection of species.

Species with the ability to fix nitrogen from the air,survive low soil fertility and build up the amount of nitrogen in the soil. Examples of such species are found in genera such as: Alnus, Amorpha, Caragana, Ceanothus, Cladrastis, Comptonia, Cytisus, Elaegnus, Genista, Hippophae, Myrica, Robinia, Shepherdia, and many others. Though able to grow in soils poor in nitrogen, such plants exhibit various tolerances to other site factors such as climate, soil pH, soil moisture, root competition and shade.

Species with the ability to spread over large areas by suckering may or may not be desirable. Some examples include the genera Cornus, Populus (Aspen section), Rhus, Robinia, Rosa, Spirea and Symphoricarpos.

Most deciduous species that are not nitrogen-fixing are rather demanding in site requirements. For best growth they require a deep, uneroded, fertile, moist but well-drained soil. Coniferous species such as pines (Pinus spp.) are more adaptable to areas of dry, exposed slopes or shallow topsoil.

In general, species that are native to the area can be expected to be winter hardy. Winter hardiness zones, based mainly on minimum winter temperatures, have been published for many species that are available in Ontario. These zones can be used as a guide when selecting among exotic species.

Planting Stock

The success of any planting will also largely depend on the quality and suitability of the planting stock. Good stock should be sturdy and have a well-branched root system.

When planting larger areas, it is usually best to use young plants grown in the nursery for only a few years. Young plants include rooted cuttings, seedlings (plants grown for 1 to 3 years from seed), transplants (seedlings that have been transplanted once) or small trees and shrubs 1-3 m tall.

Larger stock for landscaping purposes may sometimes be needed, but this is more expensive and must be well cared for during the first few years. The best survival and growth will be shown by young stock that is relatively large for its age.

Seedlings and transplants are normally purchased bare-root (where soil is not kept around the roots) and the plant must be moved while the buds are completely inactive.

However, trees 1-2 m in height should have soil kept around the roots in a root ball, either tied around with burlap (as balled and burlapped stock) or in a fibre or plastic pot (as containerized stock). Some species may be established by the use of unrooted cuttings (*Populus* spp; *Salix* spp.) or by root cuttings (*Rhus* spp. and others that spread by suckering).

The Ontario government will supply seedlings, cuttings and transplants of about 20 species at a very low cost to owners of at least 2 ha not including buildings. A wider range of trees and shrubs are available from commercial nurseries.

Wild plants may also be dug carefully and replanted on the property but this may be risky. Root pruning one or two years before digging may help by encouraging the growth of new roots. Small, shallow rooted deciduous trees growing in a clay loam soil are most easily transplanted.

INSTALLATION

Site Preparation

Site Preparation is essential for planting most deciduous species. It may be in the form of complete or partial cultivation or chemical eradication of competing vegetation.

Ploughing and tilling of the total plantation area the year before planting is the best method of site preparation. However, in erodible soils, strips up to 2 m wide may be ploughed along the contour and the trees planted in the overturned soil the following year. Chemical site preparation either before or after planting can be used in place of mechanical site preparation on stony, hilly or other areas not suited to ploughing and cultivation. Small areas can be prepared by hand scalping the sod with a shovel.

Very poor and sandy soils may not grow a very thick stand of herbaceous weeds. Site preparation is not necessary on such sites and appropriate woody species can be planted directly into the sod. Soil amendments and fertilizer can be applied at rates suggested by a soil test.

Planting

The best time to plant is in early spring, as soon as possible after frost leaves the ground. Planting in the fall is more risky as the plants may be heaved by frost if the roots are not established. However, it may be more convenient to fall plant deciduous species that flush very early in spring. Planting should be done when the plants are dormant.

Trees should be planted from 1.5 to 3 m apart. Shrubs may be planted at spacings of 0.5 to 1.5 m.

Small Stock

Planting stock under 1 m in height is usually planted by hand on steep or stony sites or on areas needing fewer than 4,000 trees. Hand planting involves making a hole with a hand shovel, placing the tree in the hole so that the roots are well extended below ground level with the stem upright above ground level, and packing the soil back firmly around the roots with the heel.

When larger number of plants are needed and gradients are accessible, a tractor-drawn planting machine with a two or three-man crew can be used. The machine cuts a trench or ploughs a furrow for the tree, and firms the soil back around it with packing wheels. Planting machines are available from the Ministry of Natural Resources and some conservation authorities. Machine planting is faster than hand planting, but

care still needs to be taken to ensure that trees are inserted upright at the correct level, with roots well spread out.

If no planting machine is available, a furrow may be ploughed with standard agricultural equipment. Trees can then be planted and soil packed back around the roots manually. Plants should be planted with topsoil around the roots rather than with roots going directly into subsoil.

Larger Stock

Plants 1 to 2 m tall are usually planted by hand. A motorized post-hole digger, either hand-carried or tractor mounted, can be used on relatively stone-free sites to reduce the amount of hand digging. A backhoe is helpful for planting the largest stock.

Whenever possible, topsoil mixed with better quality subsoil should be used in the planting hole. If topsoil is unavailable, subsoil can be improved by mixing in 1/3 by volume of peat moss, composted manure, cocoa shells or well-rotted sawdust. About 0.03 kg of a complete fertilizer such as 10-10-10 per plant should then be added to the mixture going into the planting hole. Final depth of planting should be close to the original depth of the plant.

With containerized stock, containers must be removed completely before planting. For balled and burlapped stock, any rope around the trunk is cut and removed after the tree has been placed in the hole. The burlap should be loosened and removed if practical without breaking the soil of the root ball. After the hole is

half filled with soil, the soil should be packed firmly around the root ball. Water should be added to settle the soil and eliminate air pockets. When the water has drained off, the remainder of the hole can be filled and the soil packed as before. Extra soil can be used to form a shallow basin around the tree for holding irrigation water. (The basin should be eliminated before winter to prevent ice injury).

Any corrective pruning should be done at the nursery prior to transportation to the planting site. If roots are broken or damaged the tops of deciduous trees may be cut back to balance the root system. The leader on evergreens should remain untouched.

Where practical, steep slopes should be covered with a protective mulch such as wood chips or straw to conserve moisture and control erosion. If fresh organic matter is used as a mulch, a slow release fertilizer (or an organic form) should be added as well.

A temporary cover crop of non-competitive annuals can be used as an alternative erosion control (but not with small woody seedlings) until planted materials offer protective cover. Where erosion hazard is very high, heavy jute netting or landscape mats of excelsior or fibreglass can be pegged to the slope.

MAINTENANCE

Staking on the northeast side of the plant is necessary for trees over 1 m tall to prevent excessive swaying. A wooden or metal stake is driven firmly into the ground close to the tree and

attached to the trunk by a commercial tie or a length of wire passed through a piece of rubber hose. Trees taller than 2 m may Ideally, young trees should receive about 2.5 cm of water each week for the first two years after planting. When rain does not supply this need, the trees should be watered deeply but not more than once per week. This is essential for larger stock in the first year.

On good soils, weed control is more important than fertilization for small trees and shrubs because fertilized weeds may suppress the newly planted material through root competition or by faster growth. Weeds must be controlled by either careful cultivation, herbicides or mulching around the trees for the first few years after planting. Poor soils can be fertilized according to soil test results.

Girdling by mice and browsing by ground-hogs and rabbits can cause heavy damage, particularly in deciduous plantations near grassy areas, old windrows, young evergreen plantations or natural cedar stands. Many shrubs are able to recover by sprouting more stems. Trees can be protected by wrapping the trunk with a commercial metal or plastic tree guard from ground level up to a height of 1 m. If necessary, mice populations may be temporarily reduced by the application of poisoned grain.

Staked trees should be checked before winter for two years to make sure the ties and wire are still secure. After two or three years, ties and stakes should be removed. Tree guards should also be checked in the fall to make sure they remain in place without damaging the trunk.

Health and survival of plants should be checked the first fall or the following spring. If the survival rate is low, dead plants can be replaced by replanting.

As trees grow older, little maintenance is needed. Some corrective pruning may be necessary, depending on the objectives of the planting. Limbs should be removed to avoid weak, narrow-angled crotches. Some thinning out of shrub stems may be helpful in rejuvenation and attaining a good form of growth. Damaged or dead wood should always be removed.

Trees over 15 years old may need to be thinned or spaced if there is no natural dying off of the weaker specimens.

Plantations that are too thick will stagnate in growth and the health of individual trees will be weakened. Thinning will also promote the development of a soil-protecting understorey which would not occur in dense shade.

SPECIFICATIONS

Planting Stock

1. Nursery stock shall be true to name, and of the size or grade stated. Sufficient labels or markings shall be used.
2. Nomenclature used shall conform to the latest rules of International Code of Nomenclature for Cultivated Plants.
3. Quality shall be normal for the species when grown under

proper cultural practices. All nursery stock shall be viable, substantially free from pests and disease, and undamaged. Roots shall not be subject to long exposure to drying winds, sun or frost, between digging and delivery. Root balls shall be free from pernicious weeds such as couchgrass, horsetail, thistle and bindweed.

4. Packing or wrapping shall be adequate for the protection of the stock and sufficient to prevent heating or drying out during storage and transportation.
5. All normal quality nursery stock shall have an adequate fibrous root system cleanly cut at the ends. Split roots are not acceptable. Pertinent facts as to when larger stock was transplanted or root pruned should be available.
6. Material dug from native stands or woodlots shall be designated as "collected".

Handling

1. Plants must be protected at all times from exposure to sun and drying winds by keeping the roots covered with moist material. Plants shall be shaded at all times between digging and planting.
2. Plants should be packed and tied tightly to prevent them from moving about and being damaged during transport.
3. Balled material must not be set on a concrete floor since earth balls will give off excessive moisture to

the concrete and the roots will be damaged. Burlap balls should be laid on a sheet of polyethylene.

4. Plant material shall be handled as living material and not tossed around carelessly.
5. The time between digging and replanting shall be reduced to a minimum.
6. Plants that cannot be planted quickly shall be heeled in by placing the roots in a trench, inclining the stems at an angle of 45 degrees or lower and covering the roots with soil. The soil covering the roots must be kept wet.

E.C.S.10

GRASSED WATERWAYS

INTRODUCTION

Grassed waterways are broad and shallow channels, stabilized by suitable herbaceous vegetation, that are designed and constructed to carry concentrated flows of surface water across land to a drainage outlet. The purpose is to convey runoff without causing erosion damage. The flow is retarded by the shallow grade, the wide channel and the vegetation growing in it. With favourable soil conditions grassed waterways will handle water velocities up to 1.8 m per second. See Table 10 for maximum velocities and channel slope.

APPLICATION

Grassed waterways may be used where added channel capacity or stabilization is required to control erosion resulting from concentrated runoff. They should be used where channels of the proper grade can be constructed, vegetated and maintained to achieve the required control. They are often constructed in natural draws across farm fields where water naturally collects and flows to an outlet.

TABLE 10

PERMISSIBLE VELOCITIES IN EARTH - AND GRASS-LINED CHANNELS

EARTH LININGS

Soil Types	Permissible Ft/Sec	Velocities M/Sec
Fine Sand (noncolloidal)	2.5	0.8
Sandy Loam (noncolloidal)	2.5	0.8
Silt Loam (noncoloidal)	3.0	.09
Ordinary Firm Loam	3.5	1.1
Fine Gravel	5.0	1.5
Stiff Clay (very Colloidal)	5.0	1.5
Graded Loam to Cobbles (noncolloidal)	5.0	1.5
Graded,Silt to Cobbles (colloidal)	5.5	1.7
Alluvial Silts (noncolloidal)	3.5	1.1
Alluvial Silts (colloidal)	5.0	1.5
Coarse Gravel (noncolloidal)	6.0	1.8
Cobbles and Shingles	5.5	1.7
Shales and Hard Pans	6.0	1.8

GRASS LININGS

Channel Slope	Grass Types	Permissible Ft/Sec	Velocities M/Sec
0.5%	Bermudagrass	6.0	1.8
	Reed canarygrass Tall fescue Kentucky bluegrass	5.0	1.5
	Grass-legume mixture	4.0	1.2
	Red fescue Redtop Sericea lespedeza Annual lespedeza Small grains (temporary)	2.5	0.8
5-10%	Bermudagrass	5.0	1.5
	Reed canarygrass Tall fescue Kentucky bluegrass	4.0	1.2
	Grass-legume mixture	3.0	0.9
Greater than 10%	Bermudagrass	4.0	1.2
	Reed canarygrass Tall fescue Kentucky bluegrass	3.0	0.9

* For highly erodible soils, decrease permissible velocities by 25%

DESCRIPTION

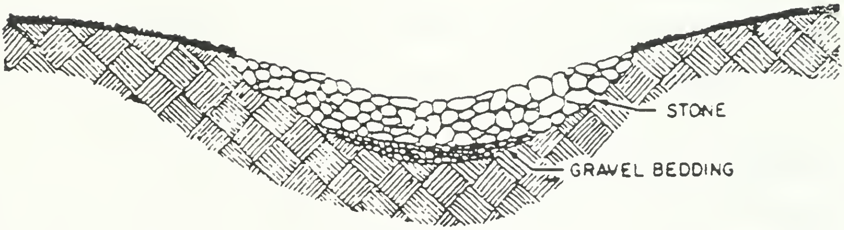
Grassed waterways are generally parabolic in cross section but can also be trapezoidal. They should be nearly flat bottomed. Constructing the waterway too deep, too narrow or v-shaped may lead to gully formation. Waterways can be designed to accommodate various grades. Ideally, the slope of the channel bottom should be about 1% (1 m fall per 100 m of channel length). Slopes of grassed waterways should also be about 1%. Grassed waterways should be constructed with shallow grades to conduct the water slowly across the land. The herbaceous vegetation in the channel retards the flow and resists the soil-eroding action of the water. Each waterway should have a stable outlet which must discharge in such a way as not to cause erosion.

Subsurface drainage should be provided for sites having high water table or seepage problems. A drainage tile beneath the grassed waterway will drain residual water, providing a channel that dries quickly after both spring runoff and summer storms.

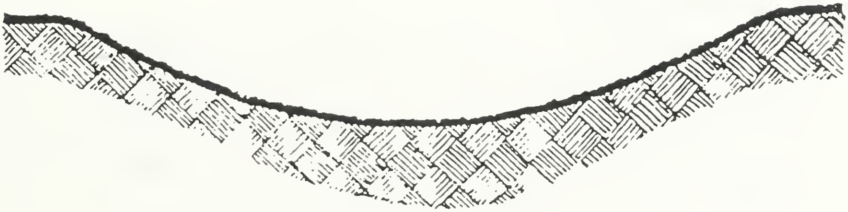
A tile beneath a waterway can also be sized to take part of the channel flow, thus reducing the required capacity and size of the waterway. Water can be allowed to enter the tile catch basins intercepting the channel flow at critical points along the waterway. The cost of a tile installation for this purpose must be weighed against the accommodation of a wider channel. To some extent, a stone centre is an alternative to a subsurface drain (Figure 5).

FIGURE 5

GRASSED WATERWAYS



WITH STONE CENTRE



WITHOUT STONE CENTRE

INSTALLATION

The outlet should be constructed and stabilized prior to operation of the waterway. Two basic outlets at a ditch are a rock chute spillway and a drop inlet back from the ditch bank.

Late spring and summer are good times for construction of a grassed waterway as the soil can generally be easily worked and grass seed will catch easily. A dry period must be chosen for poorly drained areas.

All stones, stumps and obstructions should be removed from the path the waterway will follow. The path itself should be staked for construction.

It is preferable to use grading equipment to excavate or shape to line, grade and cross section as required to meet criteria. A plough can be used to throw furrows toward the centre if the proposed waterway is gullied.

The waterway should be free of bank projections or other irregularities which will impede normal flow. The entire channel should be smoothed and compacted to prevent unequal settlement.

Topsoil should be stockpiled and re-spread where necessary to provide a good seed bed. Adequate fertilizer must be applied for grass establishment.

One mixture currently recommended for seeding in grassed waterways includes bird's-foot trefoil at 12 kg/ha and creeping red fescue at 20 kg/ha. Other possible species include brome grass, Kentucky bluegrass and white Dutch clover. Reed canarygrass survives poor

drainage conditions but may clog the channel, causing sediment deposition.

Immediate protection in critical areas can be provided by sodding. However, a mulch may be used to protect the waterway until the vegetation becomes established. Refer to Standards and Specifications for "Seeding" and "Sodding".

MAINTENANCE

Regular maintenance is important to keep a waterway in good working condition. Bare or eroded spots should be quickly sodded or reseeded. Fertilizing and mowing or spraying for weed control should be done frequently enough to keep the vegetation in vigorous condition.

Hay may be harvested. Grazing is permitted for short periods of time only, but not during wet conditions. Grassed waterways should not be used as travel lanes either for cattle or machinery in order to prevent the development of gullies.

SPECIFICATIONS

The design of grassed waterways depends greatly on:

a) Water flow in volume per second.

b) Velocity in distance per second.

c) Slope grade percentage.

d) Type and maintenance of vegetation and soil.

Detailed tables are available for calculating the top width and

the depth of a parabolic waterway from the above information. Top width increases directly with water flow and grade but decreases with increased velocity. Channel depth does not change much with water flow but decreases with increased velocity and decreases with increased grade.

1. The waterway outlet shall be constructed and stabilized first.
2. The grassed channel shall not be less than 5 m in width or less than 0.15 m in depth.
3. The design water surface elevation of the waterway should be equal to or less than the design water surface elevation of diversions or other tributary channels contributing water flow.
4. The side slopes shall rise no more than 1 m vertically to 4 m horizontally. Flatter side slopes will permit easier crossing of the channel by machinery and are preferable. The 1:4 side slopes allow for tractor mowing along the slope.
5. To control meandering low flows, the top width of parabolic waterways should not exceed 9 m and the bottom width of trapezoidal waterways should not exceed 4.5 m unless multiple or divided waterways, stone centre, or other means are provided.
6. The entire channel should be smoothed and compacted to prevent unequal settlement.
7. The site should be prepared according to Standards and Specifications for "Seeding" or "Sodding".

8. If seeding is done, it should be carried out with a suitable seed mixture within 24 hours after construction on the freshly worked, moist soil.

E.C.S.11

STORMWATER CHANNELS AND DITCHES

Stormwater channels are watercourses designed to safely convey excess stormwater runoff from the developing area. These channels shaped and lined with vegetation or structural material will ensure that the concentrated surface runoff from the site will be conveyed without causing any erosion or sedimentation. The minimum design criterion for the drainage ditches should be at least the peak flow from the 2-year frequency storm. In cases where the flooding and the resulting damage could be severe, the capacity of the channel should be further increased.

The design of the channel should be such that the flow velocity expected from the selected design frequency storm shall not exceed the permissible velocity for the soil or type of grass used. Refer to Standards and Specifications for "Grassed Waterways", Table 10.

Open ditches have the advantages that they are usually less expensive than other types of drains, and inspection is easy. The disadvantage of open ditches is that the maintenance costs usually exceed the cost of other types of installations.

The construction specification requires that:

i) All trees, brush, stumps, roots, obstructions and other unsuitable material shall be removed and properly disposed of.

ii) The final channel should have the proper grade and shape

of the cross section in order to discharge the design flow.

iii) Where fill is used to construct the waterway, fills shall be compacted to prevent unequal settlement which could cause damage in the waterway.

iv) Stabilization, if required, shall be done as specified under vegetative practices.

E.C.S.12

CONSTRUCTION ROADS AND PARKING AREAS

Temporary stabilization of construction roads and parking areas with stone immediately after the grading will reduce the amount of erosion and sedimentation.

Temporary roads should follow the contour of the natural terrain. Temporary parking during the construction activity should be located on flat areas where possible, and grades should be sufficient to provide drainage. Immediately after grading is completed, a 15 cm course of aggregate should be applied. Filter fabric may be used to provide additional stability. The temporary roads and parking areas may require periodic maintenance by providing gravel. Roadside ditches and adjacent cut or fill areas should be stabilized with temporary or permanent vegetation.

SECTION C

STANDARDS AND SPECIFICATIONS

FOR

SEDIMENT CONTROL MEASURES

S.C.S.1

VEGETATIVE BUFFER STRIP

INTRODUCTION

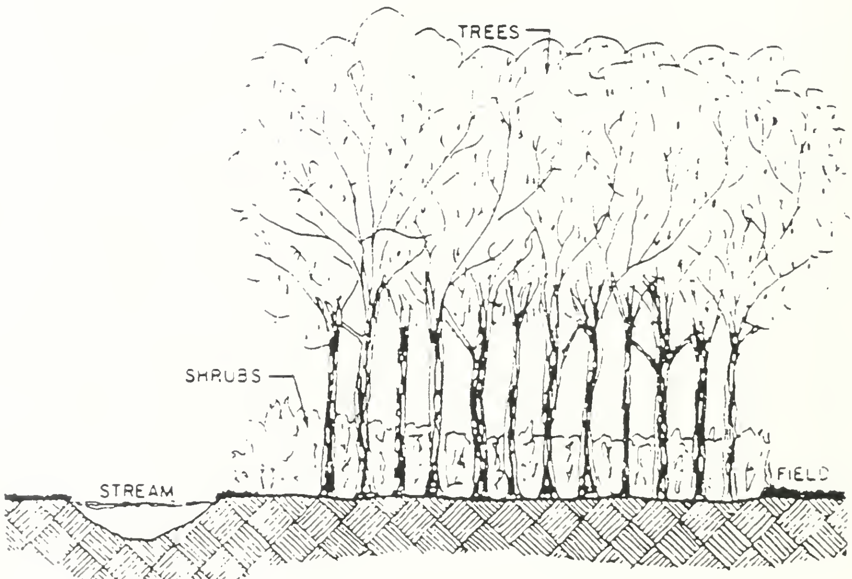
Vegetative buffer strip refers to a strip of dense vegetation that is used to prevent sedimentation or erosion by inter-position between disturbed and sensitive areas. Sediment, organic matter and other pollutants are removed from runoff by filtration and absorption. A strip of trees or shrubs can also serve as a windbreak to reduce wind erosion and soil desiccation.

APPLICATION

Vegetative buffer strips may be used to protect property boundaries, steep slopes, surface water features, and other areas sensitive to sediment accumulation (Figure 6). Buffer strips may be planted or seeded. Where possible, vegetation that occurs naturally can be retained. Planted or seeded vegetation strips generally require a substantial time before becoming effective.

FIGURE 6

VEGETATIVE BUFFER STRIP



TREED BUFFER STRIP IS TO BE AS WIDE AS IT IS HIGH APPROXIMATELY 20 METRES.

DESCRIPTION

Buffer strips are generally densely vegetated, easily maintained bands of growing plants. They may consist of grasses, broad-leaved herbaceous plants (forbs), vines, shrubs and trees. Buffer strips are oriented perpendicular to the anticipated direction of sediment flow.

Trees and shrubs take longer to establish than grasses or forbs. Once established, however, they require little maintenance and have deep and extensive root systems combined with a relatively high protective canopy.

Trees and tall shrubs are most effective for windbreaks. However, for maximum slowing of surface runoff and collection of sediment, a complete mat of vegetation at ground level is important. This is best achieved by grasses, herbaceous legumes, vines and low shrubs which will not develop properly in the shade of taller trees.

Grass or mixed grass/forb strips provide the thickest mat of vegetation at ground level. Such buffers do not need to take up as much space as strips containing trees and shrubs.

Buffer strips may be of varying width, depending on the type and purpose. The wider the strip, the more effective it will be in its filtering function.

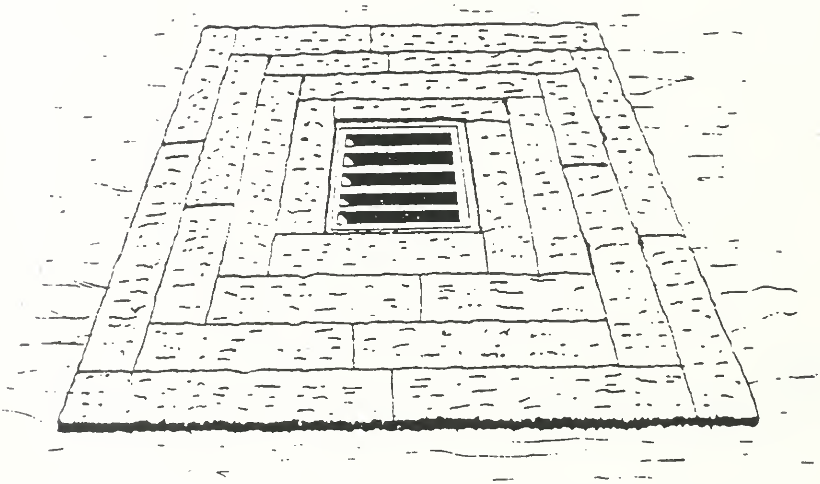
INSTALLATION

Existing narrow vegetative strips around fence lines, near streams and on top of slopes should be maintained. They may be widened by

C- 4

FIGURE 7

SOD FILTER (vegetative buffer strip)



FOUR STANDARD STRIPS OF SOD ON EACH SIDE OF THE DROP INLET

simply stopping cultivation and herbicide spraying of the areas. Natural regeneration will occur but there will be little control over species composition.

Artificial establishment of vegetation is needed in areas where the vegetation has been removed or where the existing buffer is not adequate. Eroded or steep slopes may be graded, carefully conserving the available topsoil.

Seeding a mixture of grasses and herbaceous legumes in unvegetated areas is an inexpensive method of stabilizing soil, particularly if the area is flat to moderately sloping. Sodding results in faster establishment of turf but is more expensive. Field sod, not certified as to composition, may be used where the degree of weed infestation will not be crucial. More information is provided in the Standards and Specifications for "Seeding" and "Sodding".

Where sodding, the strips of sod should be oriented at right angles to the slope (to the flow of water). Drain inlets should be completely surrounded (Figure 7).

Trees and shrubs can be established in conventional ways (see Standards and Specifications). Since it will take time for them to become effective, it may be necessary on slopes to provide a complete cover of mulch (such as wood chips) or temporary grass cover, until the woody plants become established and grow into a complete protective cover.

Where it is not practical to grade a very steep slope, terraces can be built, providing horizontal steps in which to plant vegetation. Alternatively, the slope can be broken up by the addition of "contour wattles". These are bundles of live willow cuttings which are anchored with live willow stakes in trenches along the slope face. They act as a base vegetation growth and as a strap to slow surface runoff. The willow stakes and cuttings are capable of rooting if there is sufficient moisture.
On streambanks, fascine rolls (bundles of willow cuttings filled with coarse gravel and wired tightly) can be set against the bank so that the parts which are to take root touch the ground above water level and are able to get sufficient moisture. Covering with earth improves the contact with the ground and slows the loss of moisture from the wood. Various combinations of packed fascines and willow mattresses can be used for different streambank conditions. Woody plants can also be planted in the crevices of stone facing.

MAINTENANCE

Maintenance of vegetative buffer strips will vary with the intensity of the use to which they are put as well as the intensity of natural forces working on them.
Steep slopes are always susceptible to erosion when parts of the vegetative cover fails. Restabilization, regrading and

replanting may be necessary on occasions.

Streambanks are always vulnerable to new damage and should be checked after high water events. Gaps in the plant cover shall be filled with new plants and protected if necessary. The perpetuation of a good mat of ground vegetation will be important.

Erosion and soil compaction are frequently caused by cattle grazing the vegetation in the strip. Buffer strips must be protected by fencing where required.

SPECIFICATIONS

1. Existing natural vegetation shall be retained whenever possible.
2. A mat of vegetation and/or litter shall cover the ground at all times.
3. The vegetative strip shall be located perpendicular to the flow of water (or wind) to be filtered.
4. The minimum width for grass (sod) filter shall be 1.5m.
5. A treed buffer strip should be at least as wide as it is tall, about 20 m, for effective self-support and maintenance of filtering abilities.
6. The minimum width for a buffer strip shall increase with increasingly erodible and difficult conditions.

7. Further specifications will be found in Standards and Specifications for "Sodding", "Seeding", and "Trees and "Shrubs".

S.C.S.2

STRAW BALE AND ROCK FILTERS AND BRUSH BARRIERS

INTRODUCTION

Filters remove sediment and reduce the velocity of flowing water. They can be constructed from any stabilized porous material. Such material includes straw (or hay) bales and crushed rock. Brush barriers are used as temporary filters. They impede surface runoff and stop the movement of sediment.

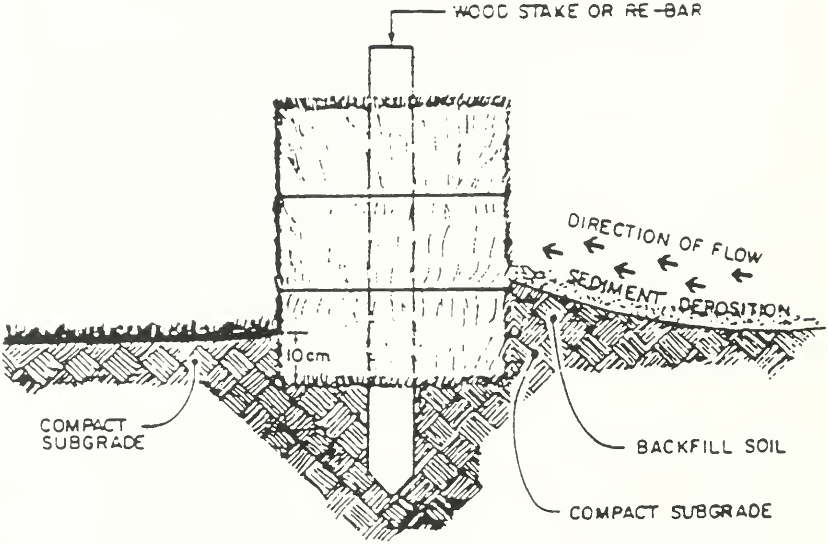
APPLICATION

Filters are used around drain inlets, along the toes of slopes, on small slopes, on sediment basin dams, between water bodies and next to downhill adjacent properties. They are used below disturbed areas subject to erosion. They should not be constructed in live streams or in swales where there is the possibility of a washout. Thus, they require an existing drainage system and are for relatively small drainage areas only.

Brush barriers are often constructed at the perimeter of a disturbed slope area, parallel to the contours. They are also

FIGURE 8

STRAW BALE FILTER



TYPICAL SECTION OF STRAW BALE USED TO FILTER OVERLAND FLOW

used in small channels to prevent gully erosion during the site construction period.

DESCRIPTION

Filters may take the form of small dams and barriers. They may be linear or they may completely surround the location being protected (i.e. drain inlets).

Straw bale filters are inexpensive. They provide an effective but temporary barrier with a life expectancy of 3 months or less (Figure 8).

Filters using rock as a filtering medium in place of strawbales have a longer useful life. However, their construction and repair may not be as simple, considering that rocks will not have the same consistent shape and will not hold together as well.

Various combinations of straw bales, gravel and wire fences have been successfully used in small temporary applications. Installations, particularly with straw, need to be removed prior to final channel stabilization. Certain types may remain semi-permanently with some regrading.

There is no predetermined shape for filters. They may, for example, surround storm drain inlets. Water must be forced to go through the filter and should never flow around it.

Brush barriers can generally be constructed from clean organic material made available from site clearing operations that is

usually discarded. The filtration ability of the barrier is enhanced if a filter fabric is anchored over it.

INSTALLATION

Straw bale filters must be embedded in the soil with ends tightly abutting adjacent bales. In sheet flow applications, bales shall be placed on the contour. Any gaps between bales shall be chinked (filled by wedging) with straw to prevent water from escaping between the bales. Loose straw scattered over the area immediately uphill from a filter tends to increase filter efficiency.

Gravel filters can be constructed by placing concrete building blocks on the inside to keep stones from being washed away. Rock filters can also be constructed in a form similar to check dams (see Standards and Specifications for "Check Dams") for drainage areas up to 4 ha.

Brush Barrier

The size of a brush barrier will vary depending upon the amount of material available and the condition of the site.

The barrier shall be constructed by piling brush, stone and root mat into a mounded row on the contour. During clearing and grubbing operations, equipment can push or dump the mixture of

limbs, small vegetation and root mat along with minor amounts of soil and rock into windrows along the toe of a slope where erosion and accelerated runoff are expected.

If a filter fabric is used, it is laid across the barrier with edges overlapping and secured with stakes in a trench immediately uphill from the barrier. The trench is then backfilled and soil compacted over the filter fabric. The fabric is also anchored with twine to stakes on the downhill edge of the barrier.

MAINTENANCE

Filters shall be inspected after each rainfall. Close attention shall be paid to the prompt repair of damage, undercutting, end runs and erosion of the filter. Sediment deposits must be removed when the level of deposition reaches about one half the height of the filter and preferably sooner.

Temporary filters shall be removed when they have served their purpose, but not before the areas up the slope have been cleaned up and permanently stabilized. Any sediment deposits shall be graded, prepared and seeded.

SPECIFICATION

Straw Bale Filter

1. Straw (or hay) bales shall be of one size, with straight

sides and square corners, tightly packed and bound with at least two loops of wire or twine. Each bale should weigh at least 12 kg and preferably more.

2. Straw bales shall be placed in a single row, lengthwise, with ends tightly abutting adjacent bales. The wire or string bindings should be oriented around the sides rather than along the tops and bottoms of the bales in order to prevent early deterioration of the bindings.
3. The filter shall be embedded in the soil to a minimum depth of 10 cm. After the bales are staked and chinked, the excavated soil shall be backfilled against the filter.
4. Each bale shall be securely anchored by at least two stakes or re-bars driven through the bale. The first stake in each bale shall be driven toward the previously laid bale to force the bales together.

<u>Rock Filter</u>

1. Aggregate for rock filters shall be composed of clean, hard, durable mineral particles free from organic matter, clay balls, soft particles or other substances that would interfere with their free-draining properties. Not more than 15 per cent, by weight, shall be flat, elongated particles. Aggregates may be

accepted or rejected based on past field performance. Smaller sized gravel will need to be supported by concrete building blocks.

2. In channel flow applications, the centre of the rock filter shall be about 15 cm lower than the outer edges.

Brush Barrier

1. The material in the brush barrier shall be piled as thickly as possible, with no large opening or sharp projections.
2. The height of a brush barrier shall be a minimum of 1 m. The width of a brush barrier shall be a minimum of 1.5 m at its base.

If filter fabric is used:

3. Filter fabric used must have adequate strength for its porosity and filtering capability. The pores should be relatively large to prevent excessive siltation and impoundment of large quantities of water.
4. The filter fabric shall be cut into lengths sufficient to lay across the barrier from its upslope base to just beyond its peak.
5. A trench shall be excavated 15 cm wide and 10 cm deep

immediately uphill from the barrier and along its length.

6. The filter fabric shall be draped across the width of the barrier with the uphill edge placed in the trench and the edges of adjacent pieces overlapping each other.
7. The filter fabric shall be secured in the trench with stakes set about 1 m apart.
8. The trench shall be backfilled and soil compacted over the filter fabric.
9. Stakes shall be set into the ground along the downhill edge of the brush barrier, and the fabric anchored by tying twine from the fabric to the stakes.

NOTE: Filter fabric is <u>not</u> recommended for brush barriers in channels.

S.C.S.3

CHECK DAMS

INTRODUCTION

Check-dams are used to prevent channel erosion by reducing water velocities, lengthening detention times and increasing stream cross-sections. The structures can be made of concrete, metal, rock gabions, wood or other durable materials, depending upon site conditions.

Straw bale check dams are very susceptible to washouts and are not recommended for channel flow.

Check-dams are usually constructed across the channel, perpendicular to the contours.

Faultily designed, installed or maintained check-dams can create far more serious problems than those they were intended to prevent.

APPLICATION

Check-dams are used where the capability of the earth or vegetative measures are exceeded in the safe handling of water at permissible velocities; where excessive slope conditions occur;

or where water is to be lowered from one elevation to another.

DESCRIPTION

Log check-dams are economical from the standpoint of material costs, since logs can usually be salvaged from clearing operations. However, log check-dams require more time and labour to install. Stone for check-dams, on the other hand, must generally be purchased, but the cost is somewhat offset by the ease of installation.

INSTALLATION

Check-Dam

The centre of the check-dam must be at least 15 cm lower than the outer edges. The maximum spacing between dams should be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam. To avoid impounding large quantities of water, check-dams should be under 0.6 m in height (Figures 9 & 10).

Stone check-dams should be constructed of 5 to 8 cm stone. Complete coverage of the ditch or swale is necessary and can be achieved with hand or mechanical placement. To reduce

FIGURE 9

ROCK CHECK-DAM

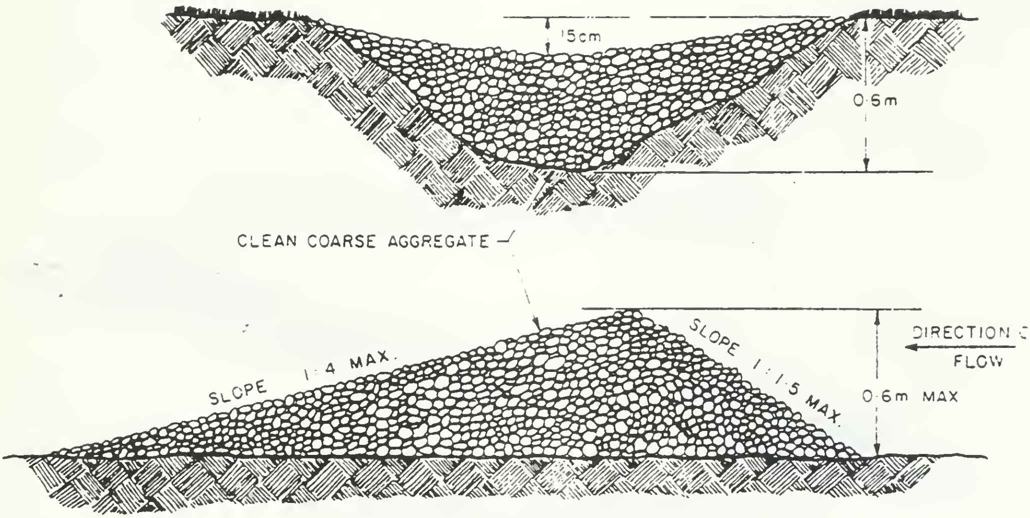
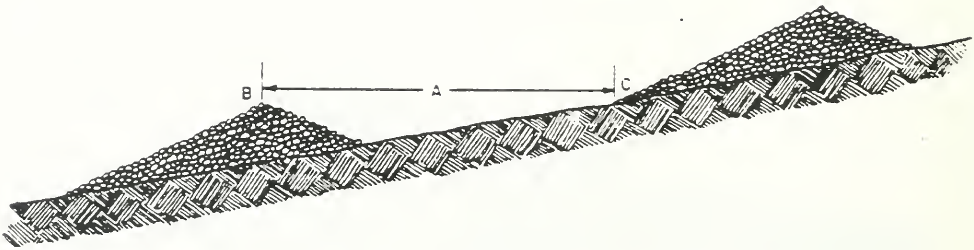


FIGURE 10

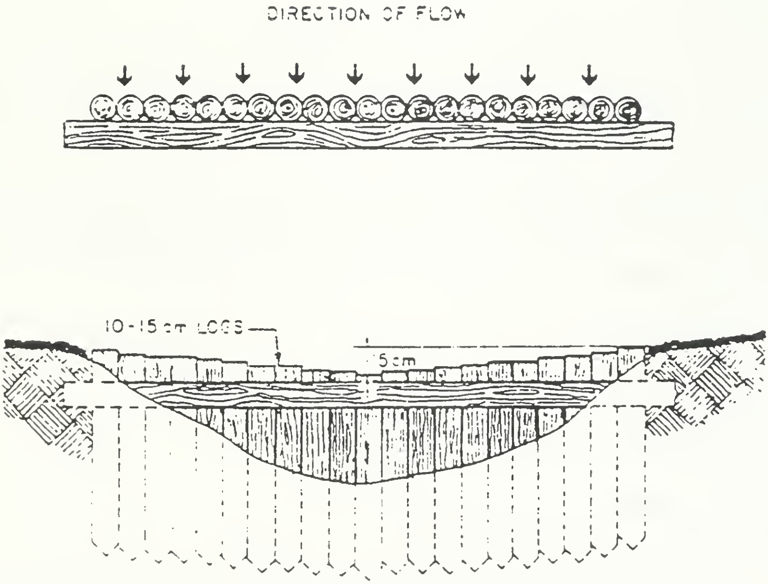
ROCK CHECK-DAMS



THE DISTANCE "A" SHALL BE SUCH THAT POINTS "B" & "C" ARE OF EQUAL ELEVATION.

FIGURE 11

LOG CHECK-DAM



destruction of the downstream side, the slope should be 1:4 (Figure 9).

Log check-dams can be constructed from 10 to 15 cm logs. The 15 cm lower height required at the centre can be achieved either by careful placement of the logs or by cutting the logs after they are in place (Figure 11).

MAINTENANCE

Check-dams and brush barriers should be checked after each significant rainfall. Necessary repairs should be made promptly, and sediment must be removed when it reaches one half of the original height or sooner.

The centre of check-dams must remain lower than the edges. Erosion caused by high flows around the edges of the dam should be corrected immediately.

SPECIFICATIONS

Stone Check Dams

1. Aggregates for stone check-dams shall be composed of clean, hard, durable mineral particles of 5 to 8 cm size, free from organic matter, clay balls, soft particles or other substances. Not more than 15 per

cent, by weight, shall be flat, elongated particles. Aggregates may be accepted or rejected based on past field performance.

2. The side slopes of stone check-dams shall have a vertical to horizontal ratio of 1: 1.5 on upstream side and 1:4 on downstream side.

Log Check Dam

1. Logs for log check-dams shall be composed of sound wood throughout and be 10 to 15 cm in diameter.
2. The logs of log check-dams shall be embedded into the soil at least 0.5 m.
3. Log check-dams must be designed to avoid undermining and outflanking around the ends.

Straw Bale Check Dam

1. The straw bales should be oriented perpendicular to the contours.
2. The straw bales shall be extended to such a length that the bottoms of the end bales are higher in elevation than the top of the lowest middle bale to ensure that sediment laden runoff will not flow around the filter.

3. The dam shall be built similar to the specifications for straw bale filter on page C13/14, items 1 to 4.

<u>NOTE:</u> In certain circumstances downstream aprons may be needed at check dams e.g. below a straw bale dam in highly erodible soil.

S.C.S.4

SILT FENCES

INTRODUCTION

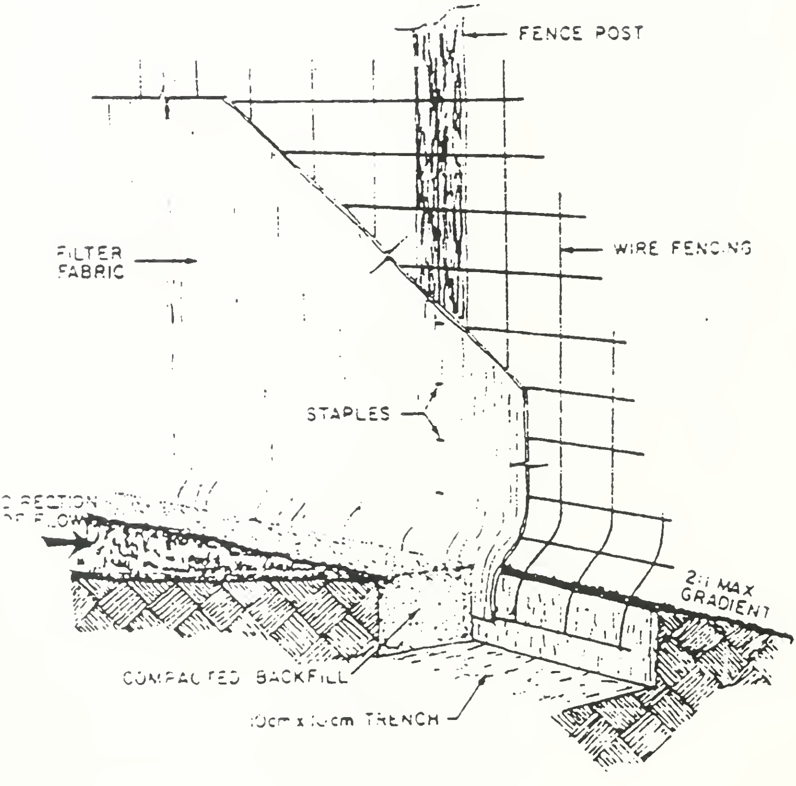
A silt fence is a sediment barrier which utilizes a standard-strength or extra-strength filter fabric attached to a wire support fence. Silt fences slow the flow rate of runoff substantially and act as a filter to remove suspended sediment.

APPLICATION

Silt fences can be used to control sediment below disturbed areas where erosion would likely occur as sheet and rill erosion. They can also be used in areas where the size of the drainage area is not more than 0.1 ha/30 m of silt fence length; the maximum slope length behind the barrier is 30 m; the maximum gradient is 2:1; and in small swales and along ditches where 1 ha is the maximum contributing drainage area. Silt fences are not to be constructed in areas where flows are expected to exceed 0.03 m^3 /sec.

FIGURE 12

SILT FENCE



DESCRIPTION

Silt fence fabric may be composed of natural or synthetic material. Woven and non-woven fabrics are commercially available, with the woven fabrics generally having higher strength. Permeability rates vary and there is considerable variation when filtering the finer silt and clay particles (Figure 12).

Silt fences of low permeability have a high filtering capacity. However, such fabrics may not have sufficient structural strength to support the weight of water ponded behind the fence line.

Posts of either wood or steel may be used to support the fence. Wire fencing may be used to help support the fabric, depending upon the fabric's strength. Standard wire and wood slat snow fencing is generally recommended.

The height of a silt fence should not exceed 1 m so as not to impound dangerously large quantities of water. A silt fence is a temporary barrier with a usable life of about six months.

INSTALLATION

The posts are first set firmly into the ground. An anchor trench is then excavated along the post line, on the upslope side of the barrier.

The wire mesh or standard snow fencing support fence (if used) is then fastened securely to the upslope sides of the posts,

extending into the trench and not exceeding 1 m above the ground surface.

The fabric is then extended into the trench and stapled or wired to the fence. The reinforced fence may be eliminated if an extra strength filter fabric and a closer post spacing pattern is used. The filter shall then be stapled or wired directly to the support posts.

The trench is then backfilled and the soil is compacted over the filter fabric to ensure that no gaps between ground and fabric exist.

MAINTENANCE

Inspection of the silt fence must be conducted immediately after a rainfall and daily during a prolonged rainfall. Repairs to the fence must be completed immediately, and any section of the fence which decomposes before the end of its expected use shall also be replaced immediately.

Sediment trapped in the filter should be removed following each storm, and when these deposits reach one-half the height of the barrier, they must be removed.

Once their useful purpose has been fulfilled, silt fences should be removed. However, this shall not occur until after the upslope area has been permanently stabilized. After removal of

the silt fence, the sediment which remains in place must be graded, prepared and seeded.

SPECIFICATIONS

1. The post used for supporting a silt fence shall be either 10 cm diameter wood or 2 kg per linear metre steel, minimum length of 1.5 m. The steel posts must also have projections to enable the fastening of wire to them.
2. The posts shall be set at a maximum spacing of 3 m and driven at least 35 cm into the ground. When a wire support fence is not used, posts shall not be spaced more than 2 m apart.
3. The anchor trench shall be approximately 10 cm x 10 cm and shall be excavated along the post line on the upslope side of the barrier.
4. For silt fences using a standard strength filter cloth, the reinforcement fence, if used, shall be a minimum of 1.1 m in height, have a maximum mesh spacing of 15 cm, and have a minimum wire diameter of 2 mm. It shall be fastened securely to the upslope sides of the posts with heavy duty staples of a minimum of 25 cm in length, or with tie wires or hog rings, providing standard strength fabric is used. The fence shall extend a

minimum of 5 cm into the trench and shall not exceed 1 m above the ground surface.

5. A pervious sheet of propylene, nylon, polyester or ethylene yarn may be the synthetic filter fabric used. The fabric, in order to provide a construction life of a minimum of six months, at a temperature range of - 18 C to 50 C, shall contain ultraviolet ray inhibitors and stabilizers. Pervious and closely woven natural fibre fabric may be used in place of synthetic fabric, however, porosity and filtering capability must be comparable to synthetic material. In order to avoid the use of joints, the fabric shall be from a continuous roll, cut to the length of the barrier.

6. 20 cm of the fabric, standard strength, shall be extended into the trench and shall be stapled or wired to the fence (or directly to the posts if a fence is not used). However, the fabric shall not extend more than 1 m above the ground surface and it shall not be stapled to existing trees.

7. The trench shall be backfilled and the soil compacted over the filter fabric.

S.C.S.5

SEDIMENT TRAPS

INTRODUCTION

Sediment traps are areas where sediment-laden runoff can be slowed in velocity, prior to entering a drainage inlet, in order to settle out some sediment. The sediment traps are simple and inexpensive to install, where an existing drainage system has an inlet and there is access for clean-out.

APPLICATION

Sediment traps can most effectively be used where drainage swales enter the municipal sewer system or a watercourse.
The use of check-dams, as described in Section C3, is a form of sediment trap. Where velocity of flow is reduced the heavier sediment particles settle out. The use of sand bags in natural waterways on a site to create small dams will cause the water to drop part of its sediment load. Similarly, the placement of large rocks in front of sewer inlets will detain and pond the stormwater. This will cause sedimentation, as well as a reduction of soil erosion at the sewer inlet.

DESCRIPTION

Sediment traps at catchbasins and drain inlets can be formed using sod, straw bales, rock, or man made fibre filters which trap the sediment before it enters the system.

Within the municipal system the "good housekeeping" practices that promote sediment traps require sumps in catchbasins and manholes, as well as weirs in the sewers. These sediment traps all require good access for cleaning out the sediment.

The underlying feature of a sediment trap is the formation of a pond to slow the rate of flow, cause sediment to settle out, and allow storage of sediment.

INSTALLATION

Sumps inside the sewer system will be limited to the physical size of the catchbasins and manholes. Weirs in the sewer should be of brick and built up to the springline of the sewer on the upstream side of a manhole. This will allow easy access for removal.

Sediment traps around inlet structures and in drainage swales should be installed as detailed in the sections for filters and check-dams.

MAINTENANCE

Sediment traps should all be inspected after each rainfall. Sediment deposits should be removed when the level of deposition reaches about one half the height of the sump, weir or filter barrier.

Any erosion around a trap in a drainage swale must be repaired to prevent wash-out.

Care must be taken when removing sediment traps, after the site construction work is complete. All sediment is to be cleaned out carefully and completely before the weir, check-dam or filter barrier is removed.

APPENDIX A

BIBLIOGRAPHY

APPENDIX A

BIBLIOGRAPHY

1. U.S. Department of Agriculture and Soil Conservation, Engineering Field Manual.
2. U.S. Soil Conservation Service, National Handbook of Conservation Practices.
3. U.S. Department of Agriculture, Standards and Specifications for Soil Erosion and Sediment Control in Developing Areas.
4. U.S. Transportation Research Board, No 221 - Erosion Control during Highway Construction.
5. State of Virginia, Erosion and Sediment Control Handbook.
6. U.S. Environmental Protection Agency, Erosion and Sediment Audiovisual Training Program.
7. M.T.C. Ontario, Guidelines for Analyzing Surface Water Sensitivity to Erosion and Sedimentation.
8. State of Michigan, Soil Erosion and Sedimentation Guidebook.
9. M.T.C. Ontario, Erosion Control and Practices - J.J. Armstrong.
10. U.S. Soil Conservation Service, National Engineering Handbook - Specifications for Construction Contracts.
11. M.T.C. Ontario, Erosion and Sediment Control, M.T.C. Drainage Manual, Chapter F.
12. U.S. Transportation Research Board, No. 70 Design of Sedimentation Basins